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ABSTRACT

More than 60 papers in this conference proceedings address telecommunications issues in the Pacific region, specifically focusing on the development, use, implementation, and management of new digital communications channels. Following a keynote address on the political and economic realities in the Pacific, entitled "Progress Report on the Independent Commission for World-Wide Telecommunication Development," by Achmad Tahir, papers are presented chronologically to reflect the focus of the three primary conference days. Papers from the first day cover the development of digital channels, including the conceptual framework and current digital developments in business, satellites (analog versus digital), fiber optics, and broadcasting. Use of the channels was examined on the second day, including requirements, information services and systems, technical and engineering aspects, local area networks, and integrated services digital networks (ISDN). Papers from the final day look at topics related to channel management and policy formation for a digital world, such as international issues; choosing technology; human resources and training; economic, social, and political aspects; networks; and satellite versus fiber optic cables. Some papers provide references. (LMM)

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PTC'85

Proceedings

Edited by
Dan J. Wedemeyer

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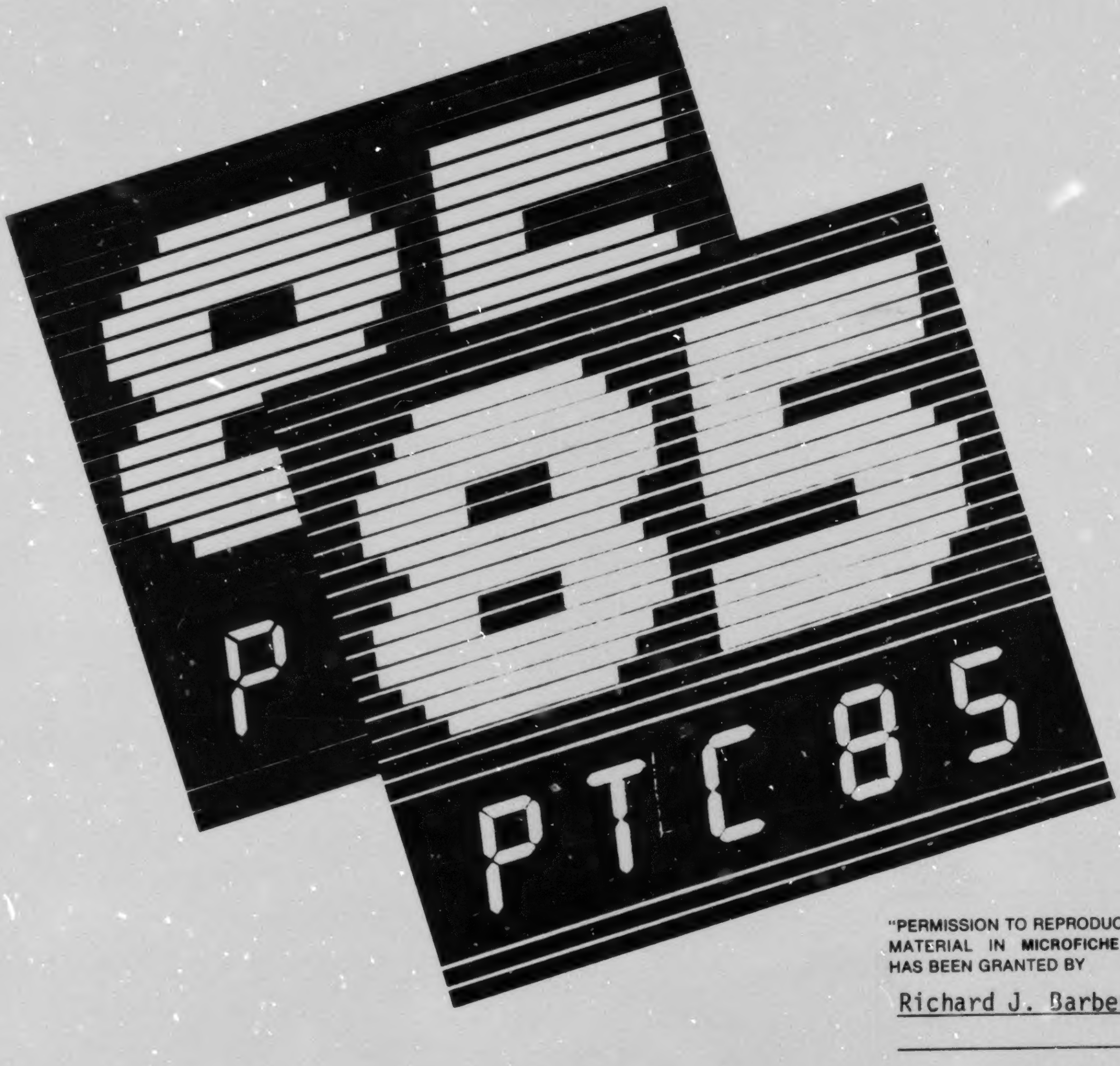

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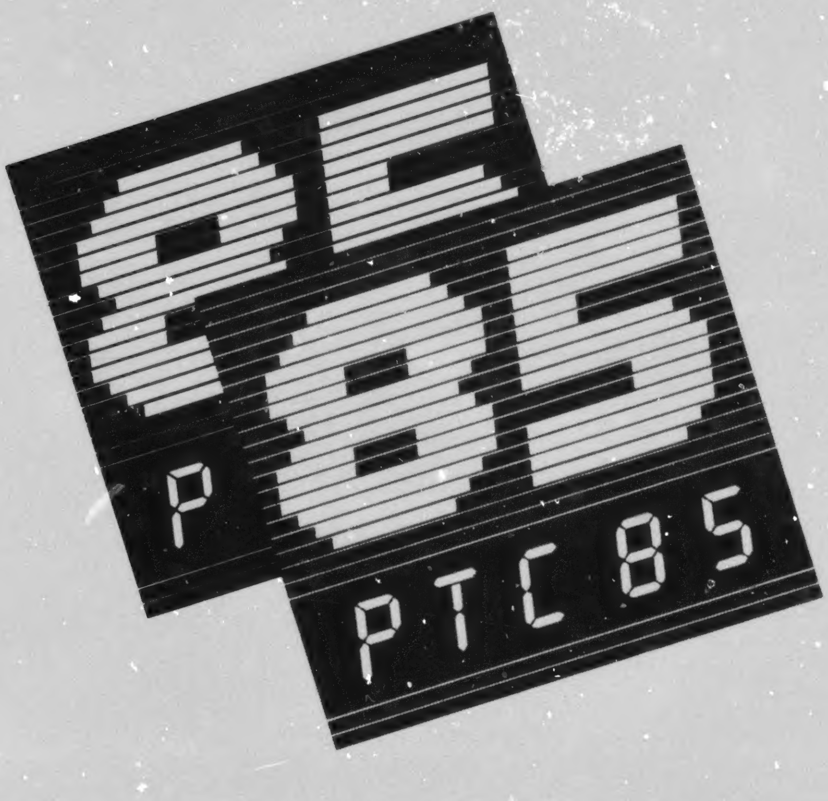
Telecommunications for Pacific Development

PTC'85
Toward a Digital World

January 13-16, 1985
Sheraton-Waikiki Hotel, Honolulu, Hawaii



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PTC '85

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Foreword

The 1985 Pacific Telecommunications Conference is the seventh session of this important annual forum. As the papers in this volume suggest, the conference has emerged over those seven years as one of worldwide importance in its field.

One indication of this is the impressive number of papers offered for presentation at PTC '85. Of the more than 100 received, a conference subcommittee selected 65 for their significant contributions to the 1985 theme, "Toward a Digital World."

One noteworthy innovation of PTC '85 is Teletrack, a series of paper presentations running parallel to the regular conference sessions but in a totally electronic format. Teletrack's intent is to increase the variety of material presented and to stimulate additional participation by presenters, while at the same time extending the ability of other conferees to hear papers on topics of special interest to them. Its format gives each selected presenter a 20-minute time slot for a live video presentation carried on the closed circuit television system of the conference hotel. At the end of the presentation, five minutes is set aside for phone-in questions from viewers. Conferees who miss a live presentation may see it on videotape at any time during the conference. PTC '85 Teletrack papers are included in this volume along with other papers presented on Monday.

The papers in the *Proceedings* are organized chronologically, parallelling the conference days. Monday's papers focus on the development of digital channels. Tuesday's discuss utilization of those emerging channels in terms of requirements, technical aspects, local area networks, and integrated services digital networks (ISDN). On Wednesday, papers address the transition to and management of the new digital networks.

PTC '85 continues the working group concept introduced in 1984. Due to the spontaneous nature of these groups, no prepared papers are included in this volume. It should be noted, however, that the purpose of these small, informal groups is to provide special attention to topic areas of special interest to group members. This concept can result in groups continuing their work over the year, and future conference papers and projects may be generated from their deliberations or findings.

I would like to thank the authors of the papers in this volume. The quality of all submissions made it very difficult for the conference subcommittee to make its final selections. Authors whose work is included should take particular pride in the overall quality of the volume and the conference. The papers contained here combined with those presented in previous PTC conferences constitute a rich resource on telecommunication development in the Pacific Hemisphere.

Aloha,
Dan J. Wedemeyer
Honolulu, 1985

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PROGRESS REPORT ON THE INDEPENDENT COMMISSION FOR WORLD-WIDE TELECOMMUNICATION DEVELOPMENT

Achmad Tahir
Minister of Tourism, Posts and Telecommunications
Republic of Indonesia

1. INTRODUCTION

We are all aware that the telecommunications technology -- especially in the electronical field has grown rapidly.

In the 21st century it is hoped that an Information Society based on the network of telecommunications information system will exist, although in reality we all realised that the above mentioned will be achieved by the developed countries only.

There are some differences on the development level of the developed and developing countries today. We could not afford if this growth of information network be accomplished only in the developed countries since as a matter of fact, Information Society could be achieved by an even level of growth; for example between North and South or even between South and South.

When will this Information Society be achieved?

We are certain that it will exist only by the willingness of the developed countries to participate in assisting the developing countries in advancing their telecommunications network.

2. HISTORY OF ICTWD

ITU with their effort in developing the world's telecommunications set up an Independent Commission for World-wide Telecommunications Development (ICWTD) in Autumn 1982 as a follow up of the Plenipotentiary Conference in Nairobi.

Those present at Nairobi recognised for the first time in the history of the Union the fundamental importance of Communication infrastructures as an essential element in the economic and social development of all countries to which the General Assembly of the United Nations had drawn attention in Resolution No. 36/40 of 1981. The mandate which they gave to the Independent Commission was to recommend ways how the expansion of telecommunications across the world could be stimulated.

The Independent Commission was established in May 1983 and we met for the first time in Geneva in October of that year. We met subsequently on four occasions in the course of 1984, as follows: in Leeds Castle, England, in May; in Munich, the Federal Republic of Germany, in August; in Tanzania in October; and the final meeting in Bali, Indonesia, in November.

The ICWTD meeting in Bali was to put the finishing touches to the work we had started the year before. The task, given to us by the 1982 Plenipotentary Conference of the ITU was, simply stated, to find ways of stimulating the expansion of telecommunication in developing countries. Our report will be released in a few days. I will leave it to you to judge then how well we have accomplished the task which was set for us.

Today, I would like to outline some of the background to our work and to mention some of our general conclusion.

Our Commission had 17 members: ten from developing countries, five from Western industrialised countries; and two from Eastern Europe. The members represented every region of the world and represent a wide range of experience and disciplines.

Our Chairman, Sir Donald Maitland, is from the United Kingdom. Our Vice-Chairmen, in addition to myself, are from Tanzania, Kuwait and Costa Rica. Some of our members had spent a lifetime in telecommunications, others had been concerned with different aspects of public affairs. From the beginning, we all recognised that our task was predominantly a political one.

We have had five meetings as I have mentioned earlier.

3. OBJECTIVE OF ICWTD

We arrived early at an objective. This is to bring all mankind within easy reach of a telephone by the early part of the next century.

We drew form the extensive literature on the subject of telecommunications in the developing world. Additionally, we corresponded with heads of governments, international and regional organisations involved in telecommunications, development and financing, telecommunications administrations, equipment manufacturers and recognised private operating agencies and scientific and industrial organisations.

Two characteristics of the telecommunications sector became clear to us.

First, there is a marked imbalance between the industrialised and the developing world in the distribution of telecommunications services. Of the 600 million telephones in the world, three-quarters are to be found in only nine countries. The remainder are distributed unevenly throughout the rest of the world. In developing countries, the level of investment in telecommunications is generally low, with services being mainly concentrated in urban centres. In two-thirds of the developing countries, there is no telecommunications system adequate to sustain essential services. In many remote areas, there is no service at all. None of the Commissioners were able to accept this situation.

Second, telecommunications play a vital role not only in such obvious fields as emergency, health and other social services, administration and commerce, but also in stimulating economic growth and enhancing the quality of life. The creation of effective world-wide networks will bring immense benefits. An increase in international traffic will generate funds which could be devoted to the further improvement and development of telecommunications services. The increased flow of trade and information will contribute to better international relationships. The process of creating effective networks world-wide will provide new markets for the high technology, including digital and other industries some of which are already suffering the effects of surplus production capacity. The interest industrialised and developing countries share in the world-wide development of telecommunications is as great as in the exploitation of new sources of energy. And yet it is far less appreciated.

4. PROGRESS REPORT OF THE ICWTD

Our Report covers all aspects of the problems, ranging from the Role of Telecommunications to Research and Development and local manufacture. Two aspects of our Report, in particular, are especially relevant to the theme of this Conference.

The first, Technology, outlines the factors to be considered in developing countries in choosing the technology to be used in its network. Digital technology figures prominently in our Report. We have recognised its overwhelming advantages and we believe that every telecommunications planning decision in the next few years should be made with the potential of a complete digital network in mind. However, a change from analog to digital is a fundamental step that will take many years to implement fully. This involves detailed transition planning to optimise costs and benefits, personnel planning to match expertise and training to the changing needs and capital planning and funding for both the growth of the system and the replacements needed to modernise it. For full benefit to be obtained, a long-term strategy, defining a complete operational and network plan, must be established.

The second aspect I should mention is that of Financing. It has been estimated that a total of US $8 billion from all sources was invested in telecommunications in developing countries in 1983. If developing countries are to achieve the improvement and expansion of their networks which we have shown to be necessary in this Report, we estimate that another US $4 billion a year will be needed. By any standards, this represents a major challenge, which is all the more daunting at a time when the world economy is characterised by indebtedness, high interest rates and low savings - all of which hinder the flow of funds and the transfer of resources.

For most developing countries, the problem is, however, not simply one of increased investment. Telecommunications require large capital sums. On average, 60% of investment in telecommunications in developing countries must be in foreign currency. Foreign exchange is scarce and costly to obtain; and most of the money telecommunications earn in in local currency.

In considering this formidable challenge, we have been encouraged by a number of circumstance which are peculiar to the telecommunications sector. First, an effective telecommunications system which meets the demand is not only inherently profitable, but also generates wealth. As soon as a telephone is installed and comes into use, it begins to make money for the operator of the system and contributes to economic activity.

Secondly, the remarkable technological advances of recent years, which still continue, have widened the options for telecommunications administrations and have driven down the costs which they have to incur.

Thirdly, developing countries represents a fast-growing and potentially the largest market for telecommunications equpment and should therefore be highly attractive to manufacturers in industrialised countries.

We have achieved a remarkable unanimity in our conclusions.

5. CONCLUSION

We have concluded that governments of industrialised and developing countries alike should give fuller recognition to their common interest and join their efforts to redress the present imbalance in the distribution of telecommunications.

There are several key elements which might fit into this joint effort.

First, in the organisation sector, we recommend to set up a Centre for Telecommunications Development with the Secretary General of ITU as its Vice Chairman Advisory Board.

The main functions of the Centre are:

a. Development Policy Unit - which collects information about telecommunication policies and experience, including experience of the role of telecommunications in economic and social advance throughout the world.

b. Telecommunications Development Service
This would advise developing countries on creating and operating an effective telecommunications system. It would offer advice on organisation and structure, planning, maintenance, training and personnel policy, procurement policy, tariff policy, integration of telecommunications with general development programmes, financing of investment and so on.
The service might consist of teams with five qualified specialists from the fields of telecommunications, management, economics, technology and finance.

c. Operations Support Group
This would provide specific assistance in preparation of plans, specification of projects, manpower planning and training, management assistance, assistance in research and development and so on.

Secondly, in financing the development of telecommunications we recommend the developing countries review their development plans to ensure that sufficient priority is given to investment in telecommunications.

Also we recommend that industrialised countries and international agencies with development assistance programmes give higher priority to telecommunications in order to increase the flow of the resources in this field and by doing so could widen the assistance project, specific provision is made in respect of appropate telecommunication facilities and services.

Thirdly, we would emphasize that the effectiveness of any telecommunications operation depends on the knowledge and skills of its staff.
We recommend that telecommunications entities in developing countries from time to time review their training needs and resources, particularly in their operational and personnel services and prepare systematic training plans.
Further, the industrialised countries should organise a seminar to improve the qualifications of experts from the developing countries in the field of telecommunications.
We also recommend that operations, both public and private, consider how they can enhance the training opportunities they offer to developing countries. This might include the provision of training equipment and of facilities.

Finally, our study of the role of telecommunications has persuaded us that it can increase the efficiency of economic, commercial and administrative activities, improve the effectiveness of social and emergency services and distribute the social, cultural and economic benefits of the process of development more equitably throughout a community and a nation.

President Soeharto of the Republic of Indonesia at the meeting of the Commissioners in Jakarta, emphasized that among the important impacts of telecommunications in Indonesia have been an increasing sense of cohesion and national identity, enhanced political stability and increased national resiliance.
It is our considered view that hence forward no development programme of any country should be regarded as balanced, properly integrated or likely to be effective unless it includes a full and appropate role for telecommunications, and accords a corresponding priority to the improvement and expansion of telecommunications facilities.

In closing, I must say that there is no single remedy to the problems of telecommunications development. What is requred is a range of actions over a wide front and at different levels.
Progress will be made only in stages. But, if the effort is sustained, the situation world wide could be transformed in twenty years. This would enable industrialised and developing countries to achieve the objective I described earlier. That is, to bring all mankind within easy reach of a telephone by the early part of the next century.

Monday, January 14

Developing the Channels

WHAT IS A DIGITAL WORLD?

Dr. Martin Fournier
Teleglobe Canada
Montreal, Quebec
CANADA

1. Abstract

The transition toward the digital world is well underway. This paper briefly reviews the status and trends in the field of telecommunications and examines the impact of recent advances in technology on service and facility development. The process of change can only be evolutionary considering the very large investments already made in building and maintaining the world-wide network necessary to support over 500 million telephones and terminals. Operational and economic considerations will no doubt constrain the evolution toward a digital world. However, challenges and opportunities are numerous and limited only by our innovative abilities and imagination.

2. INTRODUCTION

Telecommunications technology has had a profound influence on society. More recently, major innovations in micro-electronics, opto-electronics and information processing technologies are having more far-reaching implications than in any other area of human activity. Indeed, the merging of these three technologies made possible by the availability of powerful yet inexpensive solid state devices has resulted, in a relatively short period, in changing the patterns of communications beyond recognition and in creating the basis of the information society. Analogue switching and transmission techniques are giving way to reliable, high-speed, cost-effective electronic digital switching and transmission systems capable of providing a myriad of new services responsive to evolving market requirements. Communication systems based on digital techniques can process a variety of services including telephone calls, data, text, graphics and video within the same infrastructure of facilities while providing ever increasing widespread accessibility at decreasing costs.

This paper briefly reviews the status and trends in telecommunications in the context of services and systems and examines the impact of recent advances on service and facility development. It is not intended here to examine in detail the specific technologies. I will leave that to the experts who will share their knowledge with us during this conference.

With three-quarters of the world's population, the Pacific region has varied needs and resources. It is indeed significant that the large expenditures on telecommunications facilities by the Pacific Basin nations reflect the importance given to the role of telecommunications in national development and international exchanges. It is therefore vital at this time of rapidly evolving technology that efforts are directed towards effective and full utilization of the existing infrastructure while expanding the telecommunications facilities in the best and most cost-effective manner.

Although at various stages of development, the countries of the Pacific Basin have shown remarkable progress in the development and utilization of telecommunications technology. In this respect, the Pacific Telecommunications Council continues to provide an effective forum for the exchange of information on all aspects of telecommunications. Indeed, the evolving digital telecommunications environment has been the subject of considerable discussions at previous PTC conferences and of course this subject has and will continue to generate considerable interest for some time. In view of the accelerating changes propelling us into a radically new telecommunications environment, it is particularly timely to reflect on those changes and challenges and the opportunities they present to us for achieving a telecommunications infrastructure capable of serving the needs of individual nations and improving regional and international links.

3. TELECOMMUNICATIONS IN CONTINUOUS EVOLUTION

3.1 THE INFRASTRUCTURE

At present, the great majority of transmission systems in the over all, worldwide telecommunication network are of the analogue type and have analogue interfaces with their associated switches. The situation varies from country to country and a substantial proportion of the "core" facilities provided to handle toll and interexchange calls are already digital in some national networks.

The process of change can only be evolutionary considering the very large investments already made in building and maintaining the present network necessary to support over 500 million telephones and terminals. The word "toward" in the theme chosen for this conference should be interpreted as reflecting a continuing evolution of the telecommunication world. Indeed, digital technology has been used since the early 1970's and the digital infrastructure of the telephone network in Canada, in particular, has now evolved to the point where high-performance "all-digital" data connections can be established between access locations that happen to be situated sufficiently close to a digital local exchange in the telephone network. In Canada and the United States, the telephone industry is currently planning to convert 90% of local and 40% of long distance interoffice transmission links to digital systems by 1990.

In some countries, a direct digital access is afforded via satellite and/or within "digital islands". However network accesses of this type are still the exception rather than the rule and telephone local loops remain almost exclusively analogue even when they terminate on local exchange switches that are inherently digital. In an overall network environment that is still predominantly analogue, especially in the local loops at the user-network interface, a large proportion of data traffic is handled at present via modems which operate over analogue connections.

Existing local loop facilities represent a large proportion of the carriers' total capital investment in network facilities and they have a long service life expectancy. Therefore, the extension of digital communication capabilities through the local loop to the user will probably take place gradually over many years, starting with areas served by digital local exchanges and at user locations connected via copper wire pairs which can be adapted for digital operation using time burst multiplex techniques.

3.2 SERVICES

From the viewpoint of demand on transmission resources in the core network, the important categories of services are telephone, video and data, including computer communication electronic mail, facsimile and telex.

At present and for at least the next 15 to 20 years, the transmission requirements of the telephone service are expected to far exceed the combined requirements of all other service categories. This is particularly the case in-so-far as switched services are concerned since the great majority of telephone traffic is switched whereas a significant proportion of the video and data service demand will probably involve high speed traffic handled on a non-switched basis.

Out to the year 2000 the transmission requirement in the core network for all services in the data category is not expected to exceed about 1% of the telephone transmission requirement based on 8-bit PCM speech encoding. However, by the year 2000, the transmission requirement of the telephone services could be compressed with speech processing and interpolation by a factor of up to 8 or 10 in the core network. In that event the total transmission requirement for services in the data category could account for as much as 10% of the telephone transmission requirement.

Transmission resources required to satisfy video service requirements are likely to vary widely from one segment of the core network to another. By the year 2000, video transmission requirements for teleconferencing and in support of broadcast services may typically total 20% to 30% of the telephone transmission requirement on some routes if an 8-bit PCM speech encoding standard applies. Depending on the relative speech and video processing compression that may actually prevail, the same telephone and video service demand could result in a video transmission requirement that equals or exceeds the requirement for telephony.

Within the data communication category it is foreseen that computer communications will account for 80% to 90% of the total traffic volume in the 1990 to 2000 time frame with the balance of data traffic divided about equally (5% to 10% each) between facsimile and electronic mail in the countries which use a phonetic alphabet. The telex service generates a substantial number of paid minutes however, because of the associated low-speed rate of transmission it accounts for only a fractional percentage of the total data transmission requirement. Whereas facsimile and electronic mail services will be accommodated mostly within the switched digital network, it is probable that a considerable proportion of the total data volume for computer communication may be handled at high speed on a non-switched basis.

Based on the foregoing overview of the evolving service environment, it is clear that one must be able to justify implementation of a digital network infrastructure based on its relative advantages in respect of the telephone service. In many instances a second consideration of significant importance may be the relative advantages of digital transmission for video services.

In addition to the transmission and switching functions which are part of the basic telephone and data service offerings, there will also be a wide range of supplemental or enhanced services that may be provided alternatively by the carriers in their network facilities, by intelligent functions within the users' terminal equipment or by routing calls through value added service facilities of information processors located external to the network. Competition between these three alternative areas of provisioning for supplemental or enhanced services has already impacted to some extent on the development of Integrated Services Digital Network (ISDN) concepts.

3.3 TECHNOLOGY AND SYSTEMS

Digital communication technology is being swept rapidly forward, riding on successive waves in the development of solid state devices and ongoing enhancements to processing techniques for the production of VLSI circuit configurations. Computer techniques now facilitate the custom design of VLSI chips and there is a continuing trend towards reduced power consumption, higher packaging density and improved performance and reliability. Semiconductor memory devices measuring less than 1 cm by 1 cm and capable of storing the equivalent of 15 pages of a book are presently available and a chip offering four times this capacity will soon be marketed.

These advances in micro-electronic technology have had a multifaceted impact on the planning of future telecommunication networks. On one hand, they have established a technological foundation for large-scale production of reasonably priced electronic messaging facilities, intelligent telecommunication terminals and personal computers and for "wired offices and factories of the future", all of which are expected to create a future demand for digital telecommunication services. On the other hand VLSI technology has afforded a technically and economically feasible means of network provisioning to meet such a demand, leading to the development of new concepts now being internationally standardized for integrated services digital networks (ISDNs) and for the development of associated standards in respect of digital PABXs, LANs and user terminals.

Whilst the technology of hardware is generally well established, a formidable amount of design work and software development still lies ahead to prepare for the production of equipment which marries the VLSI technology and the newly standardized ISDN concepts. Large commitments of skilled human resources and capital will be required for this purpose. Already, in most R&D laboratories in the industries, almost half of the scientists and engineers are involved in the development of software and its products.

In reviewing the basic technologies which contribute to state-of-the-art digital telecommunication, it is important to note the advances being made in respect of software development. With equipment hardware costs on the decline as a result of steadily improving VLSI production techniques, software is all the time assuming more importance as a cost factor in the implementation of digital telecommunication systems. Development of the 7-layer Open Systems Interconnection (OSI) model as an architectural concept is viewed as an important step towards the development of modularized software. With clearly defined interfaces between each layer of the open systems architecture, it is possible to independently improve the functions and associated software for any one layer at minimum risk of adversely affecting functions implemented in other layers.

In view of the growing complexity of telecommunication facilities and the permutations and combinations of functions that may be involved in meeting various service requirements, the concept of a layered system architecture and modularized software is very advantageous and dovetails with a parallel trend towards distributed processing.

Distributed processing, an important new design technology in its own right, has become possible with the commercial availability of reasonably priced VLSI microprocessor components. With the advent of distributed processing the overall capability of a digital system is not necessarily constrained by the maximum speed and memory capabilities of its central processor. Furthermore, capital investment in distributed processing capabilities tends to track the system growth whereas with centralized processing the initial system cost typically includes an excess capability for processing that may only be needed in the distant future.

4. THE FUTURE

With regard to VLSI component technology I feel safe in predicting a continuing trend towards higher speed of semiconductor operation and decreasing costs. Every week brings news of specific new developments contributing to this trend. For example, a shift by another manufacturer towards gallium arsenide as the semiconductor material or the announcement of a new process or structural configuration which allows for the production of devices with narrower gate widths. Therefore, it would be rash to attempt any more detailed prediction concerning the future of VLSI component technology. The future development of integrated fibre optic component technology and its potential deployment in new generations of wideband digital switches is an interesting area for speculation.

New ISDN standards being developed by ISO and the CCITT should herald an era of world-wide functional compatibility in respect of terminals, switches and networks. I will go out on a limb and predict the likelihood of substantial changes to the ISDN user part of CCITT No. 7 signalling to bring it into full alignment with the seven-layer OSI architectural model. The impact of such a change in concept could be a potential delay of up to one year with respect to planning for the 1986 to 1990 time frame. It may also be expected that any such delay would be caught up by the mid-1990's.

From a network viewpoint, we can foresee a transition to a new numbering plan and a revision of routing procedures. Operation, maintenance and administrative functions will become increasingly automated. With increasing automation and functional complexity in both the user-terminals and the network, accompanied in some major countries by policies of terminal interconnection, the user must have better test loop access into the network and the carriers need better test loop access to the terminal interface so that each can verify the proper operation of facilities for which he is responsible.

Subscribers in the future digital network will generally be more sophisticated and discriminating in their demands for meaningful performance guarantees. The performance parameters used by the carriers for network design purposes will have to be mapped to corresponding sets of end-to-end customer service parameters that can be verified from the user terminal positions.

CCITT No. 7 common channel signalling and messaging capabilities should make it possible for any switching node along a connection path through the network to have access to all the call record information available at the originating and terminating end office switches. This will enable carriers handling interexchange toll calls and transit traffic to verify revenue settlements and, where appropriate, to undertake their own direct billing of customers. On this basis the future call recording capabilities of switches in the core network and new off-line data processing capabilities will need to be developed at a significant cost to the carriers.

Carriers, particularly those in smaller countries, may be well advised to join forces in a shared effort to develop software for off-line data processing based on a standardized set of call recording functions and agreed off-line processing objectives and procedures.

Over 50% of the circuit capacity in intercontinental segments of the international network is expected to be digital by the mid-1990's. This will approach 100% by about 2007 as existing analogue transmission facilities reach the end of their design life.

A similar trend is expected in the interexchange and toll transmission segments of national networks as the momentum of digital technology leads manufacturers to discontinue the ongoing support and relatively labour-intensive production of analogue equipment in favour of more cost-effective digital facilities.

Fibre optic cables are likely to afford the most cost-effective means of transmission on very high capacity routes in the core network. However, global coverage satellite systems will continue their function of providing extensive interconnectivity of large numbers of earth stations for major traffic streams as well as serving remote areas, islands and sites in mountainous terrain. Digital microwave systems appear best suited to meeting future transmission needs on medium capacity routes and on routes through mountainous terrain.

By about 1988, 32 k bit/s speech encoding and digital speech interpolation techniques will start to be employed on some international and long haul national toll routes to achieve bit rate compressions of up to 5:1 for real-time voice transmission.

Packetized speech transmission techniques using lower bit rate speech encoding, for example at 16 k bit/s, are likely to be standardized within the next 4 to 6 years for use in store-and-forward voice messaging service applications. Packetized speech service for real-time voice transmission may or may not become a viable possibility during the 1990's.

Two existing constraints on the use of speech encoding at rates below 32 k bit/s to provide real-time circuit switched voice service are the degradation in performance at each analogue/digital interface in the network and the present need to handle voice-band data in lieu of speech. Both of these constraints will diminish in future as the core network becomes substantially digital to reduce the maximum number of analogue/digital conversions in a connection and as data traffic is shunted to packet-mode and ISDN-type all-digital circuit mode connections that should become a more cost-effective means of data transmission in future. Therefore, during the 1990's it is foreseen that speech encoding at 16 k bit/s or possibly at lower bit rates will be standardized for use in the ISDN.

On high capacity routes where the installation of fibre optic cables is justified, the incremental cost of providing additional transmission capacity may be so small that the application of low bit rate speech encoding and interpolation techniques cannot be justified.

Towards the mid-1990's it is expected that digitalization will have spread from the core of the network and be permeating the local user access environment. As analogue local office switches are supplemented or replaced by their new technology digital counterparts, it will probably prove advantageous as a long term investment to extend digital access through the local loop to the subscriber premises in accordance with ISDN standards. With advances in technology by the mid-1990's the extra cost for converting local loops to digital operation may be relatively small or non-existent within a radius of about 7 kilometers from new digital local office installations. By that time it is also likely that new designs of remote subscriber concentration equipment will have extended the distance from the local office for which a transition to digital technology in local loops can be justified.

The transition from analogue to digital operation over the next 20 to 25 years will require interim provisioning of interworking interfaces in the core network and in some instances will create a need for terminal adapters at the user premises. The problems of interworking may become magnified where it is not possible to achieve a one-for-one mapping of functions from one network into another. Therefore it is important that new ISDN concepts be developed in a way which facilitates interworking and minimizes associated provisioning costs at the interworking interfaces.

5. CONSTRAINTS

The technical concepts and functional requirements for future integrated service digital networks must be well defined by recommended international standards as a starting point for widespread digital network implementation. Therefore an important constraint is the rate of progress in development of such standards, primarily by the CCITT and ISO. In-so-far as technical standards are concerned, they may be sufficiently completed by late 1985 or early 1986 to serve as a basis for equipment design. However, much work still has to be undertaken in the definition of service features and studies are only expected to start in 1985 for the development of new tariff principles and of concepts for maintenance, operation and administration of ISDN's. On this basis it appears unlikely that recommended standards for these aspects of the future digital work will be agreed prior to about 1988.

The high initial cost of software development and of initial VLSI design and tooling for the production of ISDN network facilities and user terminals represents a probable constraint in that some manufacturers will probably see reduced risk of rework by delaying entry to the market pending completion of field trials to prove the validity of newly developed concepts and standardized procedures.

Limitations on the availability of capital, or constraints on capital expenditure for other reasons, are likely to restrict the rate of transition from analogue to digital technology for many administrations or carriers, particularly in view of large one-time, up-front charges that may be demanded by the equipment manufacturers for the initial provisioning of software needed to operate computer-based ISDN facilities such as exchange switches.

The dilemma faced by many carriers is whether to accommodate growth requirements of their networks by enlarging the capacity of existing analogue facilities or alternatively by providing new digital transmission and switching systems.

Typically the provision of new digital facilities involves a large up-front capital investment for common hardware and software which is usually offset by lower incremental costs for subsequent circuit expansion. An early transition from analogue to digital operation may incidentally involve an increased risk of software change to accommodate revision of functional requirements covered by internationally recommended standards which are incomplete or more or less provisional in nature. Better equipment designs based on later generations of VLSI technology may also become available if the initial transition from analogue to digital operation can be deferred.

On the other hand, incremental costs for enlarging existing analogue facilities are steadily increasing compared with corresponding incremental costs for digital facilities. Moreover, the expansion of existing analogue equipment installations undertaken at this time may be subject to high rates of depreciation in anticipation of early obsolescence. Contrary to countries where extensive analogue networks are in use, developing countries may be attracted to the latest digital technologies since the optimization of very large investment in an analogue infrastructure may not be a financial constraint.

The attractiveness of the digital option increases with the passage of time and we will soon be at the point (if we are not already there) when it will be preferable to accept possible risks in respect of making a transition to digital technology in lieu of incurring relatively large incremental provisioning costs and high depreciation for the expansion of existing analogue facilities.

Poor economic conditions and resulting slowed-down traffic growth tend to impose related constraints on the timing of digital network evolution. With the recently experienced slowdown in rates of traffic growth, there is reduced pressure to expand network facilities using new digital technology. Furthermore, high interest rates and general unavailability of capital in times of economic recession result in cutbacks of capital spending that typically impact first on areas of new development.

6. CHALLENGES AND OPPORTUNITIES

A major challenge in implementing the new digital world is the achievement of international accord on standards that make effective use of the available new technologies. I am pleased to note the results of work achieved in international organizations such as the CCITT and ISO which indicate the large measure in which this challenge is being met.

It will be important to realize efficient utilization of network facilities in providing services that conform to internationally recommended norms for performance and availability. For example, the very high capacity of fibre optic cables tends to result in less routing diversity and may create problems of restoration that can adversely affect continuity of service. Furthermore, the potential user capability in some countries to specify a choice of carrier or of routing could tend towards more congestion and less efficient utilization of network facilities. The challenge is to devise new network dimensioning strategies and operating procedures which offset these potential difficulties. One possibility is the development of enhanced network management procedures to take full advantage of common channel signalling facilities in the network and processor capabilities at the switching modes to rapidly control and alleviate congestion.

In some instances, survival in an environment of providing competitive telecommunication services may constitute a fundamental challenge. We see a growing trend towards competition between carriers accentuated in some areas by the possibility to bypass established local loops at the user access. There is also competition between the carriers and other interests to provide intelligent service functions which can be undertaken alternatively in the network, in processor-based user terminals, or in facilities operated by information processing service providers external to the network. The whole subject of software development and software quality assurance is one that presents a formidable challenge. The relative cost of software development, testing and debugging in the design of real-time digital operating systems continues to be very high, schedule delays are common and latent software anomalies all too frequently result in "crashes" that disrupt system operation and cause loss of revenue. Better techniques of software reliability assessment and quality control are needed.

The wide range of service offerings that are made possible by new digital network facilities opens a new vista of opportunity for telecommunication entrepreneurs. With today's relatively high postal rates and mail deliveries that tend to be highly variable from the time of entry into the mail system to the time of delivery, it is surprising that store-and-forward messaging, facsimile and teletex services have not already captured a larger volume of traffic from the traditional postal service. Some reasons for this may be a dearth of comprehensive directory information combined with terminal costs that are more than the average potential user is willing to pay. The potential to expand electronic messaging and mail services is at once a challenge and a very real opportunity for the carriers. In particular, store-and-forward messaging offers the opportunity to make more efficient use of available network facilities with increased traffic volume in off-peak hours.

There is an opportunity for information service providers to step in and offer a comprehensive directory information service to facilitate the exchange of information between users who do not carry on a regular correspondence with one another.

The home and small business market for low cost facsimile and text terminals presents an opportunity for the terminal manufacturing industry.

The evolution to today's mobile telecommunication services and the ultimate development of cellular radio capabilities to afford a "personal" telephone service are noted as other areas of potential opportunity.

Opportunities in the evolving digital world are constrained as much by the limitations of our innovative abilities and imagination as by available technologies and financial resources. Possibilities which appear futuristic and remote today may become very realistic in a shorter time that anyone imagines.

Traditionally, transparent communication services provided by the carriers have been constrained to faithful reproduction (subject to specified error performance) of wave forms and text at the input and output of connections through the network. Over the years a more liberal interpretation of telecommunication transparency has evolved which embraces conversions of information format and coding that preserve the intent or meaning of the information. For example, video transmissions may be converted between 525 and 625 line standards of NTSC, PAL and SECAM and conversions are possible between text and facsimile information formats.

A futuristic outlook at service opportunities in the next century (which is a mere 16 years away) indicates the possibility of conversion between voice and text, a more remote possibility of language translation in respect of text messaging services and ultimately perhaps a workable real-time language interpretation service in respect of voice telephony through the international network.

7. CONCLUSION

The constant advances in the areas of solid state micro-electronics and opto-electronics providing new technological features with attractive cost benefits and the growing demand for new digital communications services of all types are the two principal factors which contribute to the trend toward the digitalization of the telecommunications network.

Digitally encoded information, be it voice, data, video, text, graphics or network control information, can all be handled in a uniform way making possible an integration of services within a single network structure.

The transition toward the digital world is well underway. It is critical that this major change occurs in an organized manner in order to ensure continuing effective utilization of the existing networks and facilities while at the same time introducing the new digital systems. Clearly this will require that digitalization concepts and strategies be such that present and future service demands can be met in an optional way technically, operationally and economically.

Some administrations will choose to move more rapidly than others. Each will have to develop a strategy of transition. However, the network must continue to serve all users on a world-wide basis and therefore it is essential that the move toward the digital world be orderly and well coordinated in the spirit of international comity.

8. ACKNOWLEDGEMENT

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INS and Communication

- International and Domestic

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It is a great honor for me to be given a chance to speak to this respectable audience at this important occasion.

Between 1972 and 73, I was invited to serve as the Director of the Communications Institute of the East-West Center. I learned a great deal while I was in that post, rather than to teach others by whatever wisdom I might had to those colleagues and friends of EWCI.

In 1972, late Professor Harold Lasswell of Yale University, then the President of the National Association of Political Science was invited to our Institute to give a talk on the subject of the Prospects of International Communication.

In his speech he stated that International Communication will become increasingly important in the future. He stated, however, depending upon a question of whether what he named the Oligarchic Communication will become far more important than the Participatory, or the latter more important than the former, and finally whether the two processes shall become complimentary will decide the future course, not only of International Communication, but also of International relations.

I think what Prof. Lasswell stated has become an increasingly important problem. Today we speak of high technology and, in the field of Communication, progress of INS.

Whether INS shall be used only by the elite or also by the masses will be an important question. Also whether human beings shall be able to use INS in the wisest sense, or whether as C.P. Snow pointed out already in the 50s, the progress of science and technology will be separated from the deep human concerns and interests shall remain just as important a question.

In other words, whether the two cultures, that is the Culture of Humanities and Social Sciences and that of science and technology shall remain separate will be serious question.

Having stated these questions at the outset, now let me discuss the following five points.

1. Historical Background

With a few exceptions, the Asia-Pacific areas had been the colonies or half-colonies, until the end of World War II, of the industrially advanced countries of the West or Japan.

Of course such independent countries as Australia, New Zealand and Thailand existed. But Japan, which had been independent from the latter half of the 19th century, was defeated in the war. During the following dozen or so years, Japan's main national goal was the recovery of her independence and economic rebuilding. Japan could little afford to involve herself actively in international communication.

The Republic of China had become independent following the 1911 revolution. But the civil wars continued and outside powers such as Japan invaded into the country. In 1949 the People's Republic of China was founded following the revolution. In this case, too, the country is not believed to have grown enough to permit herself to participate actively in international communication.

From the latter half of the 1940s into the 1950s, and into the present, former colonies in the Asia-Pacific areas achieved political independence. Yet, for many of these countries, economic development has been, and still is and important task that awaits solution. This is well explained by the fact that in the 1974 U.N. General Assembly the new international economic order was proposed as a new agenda item and the resolution was adopted.

The Asia-Pacific region is not yet a mature community of independent countries as Europe. It is still in the process of formation and development.

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2. Receiver of International Communication

Against the historical background described above, the greater majority of the countries in the Asia-Pacific region have had to remain in the position of receiver rather than sender as far as international communication is concerned.

In the fields of politics and military affairs, economy, science, culture and education, senders of communications have been the countries in Europe and the United States. The Asian countries have been working for development by receiving the flow of information.

The question of the new world information order that has been under worldwide discussions since the latter half of the 1970s represents an effort to grope for ways to build a new order of wider international balance, an order in which the Asia-Pacific countries play not only the role of receiver of international communication but also that of sender.

But, as the United States or some of the European countries point out, it is necessary in international communication to respect freedom as well as balance domestically and internationally. To achieve this target the further studies are needed.

In the meantime, Samachal of India, Antara of Indonesia and NHK of Japan have been endeavoring for the development of new communication. It must be remembered, however, that such efforts are just a step forward and still in a stage that can be expected to attain more growth through future efforts.

3. Scientific and Technological Renovation

Meanwhile, from the 1970s into the 1980s, there occured worldwide renovation in science and technology with regard to information communication.

INS, or information network system, including digitalization, development of international communication by satellite, optical fiber communication, CATV, and widespread use of computers which is a step forward from radio and TV, has entered the phase of planning and implementation internationally and domestically.

What is importyant in making good use of such renovation in science and technology is to take the historical background discussed earlier into full account.

Concerning information-communication, gaps in the degree of development still exist today between the developing countries and industrially developed countries. One of the things that should be heeded in the future is to strive for keeping the existing gaps from widening further.

Fortunately, in the East Asia coastal belt zone, there are economic areas which are entering an intermediate stage of development, a stage which the O.E.C.D. refers to as N.I.C.S. There is the urgent need of strengthening the infrastructure of information communicaiton not only in the areas I just mentioned but also in other areas of Asia-Pacific. For that purpose, all the countries and all the peoples of this area should spare no effort to cooperate.

4. Mutual understanding and Development within Asia-Pacific

In Asia, there are regions, such as India and China, that have given birth to outstanding ancient cultures. Japan today, for example, has been deeply influenced by those excellent ancient cultures. Yet, if we were to say that the countries of Asia have already achieved their mutual understanding, that would be far from the truth. Some epoch-making endeavors need to be made in promoting exchanges of students, professors and information. And in order to do so, the mass media, too, must make efforts on their part. It is necessary for all of us to endeavor to deepen mutual understanding of each other's cultures; not only those in the Asian region but also those in the Pacific as well.

At the same time, as I mentioned previously, 'development' is the urgent task to be tackled by many of the countries of Asia-Pacific. Today, Japan is counted as one of the important economic powers of the world. But until around the latter half of the 19th century, Japan was still in an underdeveloped stage. Even after the end of World War II, Japan had to go through the hardships of rehabilitation and development.

Through the development of international communication in Asia, the countries in this region must not only deepen their mutual understanding but also establish a system of cooperation by which to promote the development of each country.

Persons of my age born in Japan late in the 19th century and early 20th century remember clearly how difficult it was for Japan, an underdeveloped country to come to the stage of development. A new political system had to be built and an economic development had to be designed carefully both in private and public sectors.

Needless to say that school education also had to be built by the dedication of planners and teachers.

In these days there is a tendency to think that the highly developed INS could suddenly alter and overcome difficulties of developing countries. Such shall not be the case. All of us must co-operate closely and make utmost efforts to build up steadily infrastructures for development in so many developing counties in the regions of Asia-Pacific.

5. From Asia-Pacific to the World

What the inhabitants of Asia-Pacific are concerned about is not just the interest of this region alone. Through the concerted efforts of many a country in this region, the weekly Asian News called Asia Vision is already on the air in the countries participating in the news exchange. This type of activities of the ABU, however, must not be confined to this region. ABU should gradually extend the activities so as to promote collaboration with the ABU.

In Asia-Pacific, there are huge socialist countries, such as the People's Republic of China, as well as the countries of free economy. The People's Republic of China, as you know, is one of the important member countries of the ABU that are the major producers and users of the Asia Vision. It is most essential for the ABU to reinforce communication with this great country and also to open up ways to promote communication with the Soviet Union and the East European countries.

Fortunately, there already exists an established link of communication between Asia-Pacific and North and South Americas. For the ABU, the tasks to be tackled include the further strengthening of such communication with the Americas and the promotion of communication with African and the Arab nations.

What the people of the world today are most concerned about would no doubt be the question of peace.

The earth is a place of life that has already shrunk in size, but, for mankind, there is nothing that can replace this earth.

It is the new challenge for the world history as it proceeds from the 20th to the 21st century that the countries of Asia-Pacific should achieve independence in the true sense of the word and establish a new community of nations.

In addition, in the vast Ocean of Pacific, the cultures of the West and East are meeting for the first time in human history in the deep sense. Those who belong to the countries of Western Civilization are now studying languages and cultures of the East, just like those in the East who felt it necessary to learn from the cultures of the West for many years.

In the economic areas too, business transaction, co-operation, competition and friction are increasing in number every year.

In a word, the Pacific is becoming a place for encounter and dialogue of many different cultures and interests.

No longer could we think that the world shall remain to be monocentric basing its integration only in the West. It is getting to be multicentric. A question remains as to whether this new trend will lead to fragmentation or a more fruitful deeper and wider integration.

The Asia-Pacific community should not be a closed one; nor should it be self-conclusive.

For this region to be opened up to the world and to contribute to the progress of world history and peace.....that, I believe, should be the aspiration of the majority of the peoples of Asia and the Pacific region.

Emerging Information Services in New Zealand

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1. Abstract

Because of New Zealand's widely scattered population and its geographic isolation from the rest of the world, communications have always played a major part in the country's economy. Rapid progress is now being made in building a new digital network that will both upgrade and expand existing voice communications as well as lay the foundation for New Zealand to enter the information age. Videotex and teletext services are now emerging; new databases are being established. This paper discusses these developments and considers likely future directions.

2. Introduction

New Zealand already has in place nationwide communication services reaching into virtually every home and business in the country (1). 96% of all households have a telephone. 98% have a television receiver. Most households have numerous radio receivers and a rapidly growing number have home computers. The information technology is in place. The communication networks are in place. New information services are emerging. The stage is set for a rapid transition to the information age.

This paper discusses the development and application of two particular information services in New Zealand - videotex and teletext - as well as some related database developments. In terms of world developments, neither videotex nor teletext is particularly new; both have been in operation in a number of countries for some years now. In New Zealand, however, both of these services were only introduced last year. As a result we have been able to benefit from early experience in other countries and target our applications more directly at user needs. Videotex and teletext have often been referred to as technologies in search of a market. In New Zealand, we believe we have found a market and initial growth patterns certainly appear to be confirming this. In less than six months from the introduction of videotex, there were approximately 600 users. Nine months after the introduction of teletext there were approximately 7 000 users.

3. Today's Information Services

Despite New Zealand's comparatively small population, the country has been well served with the traditional information services. There are 31 different local daily newspapers and over 70 weekly publications. In addition there are well over 150 monthly special interest journals and despite the growth of electronic information services, new journals and magazines continue to flourish. Many are a direct response to a public desire to know more about the emerging electronic information services (2).

Complementing the print media, we have over 70 broadcast radio stations and two television channels. Over 50 of the radio stations as well as the two TV channels are owned and operated by a Government Corporation (the Broadcasting Corporation of New Zealand). Planning is also underway for a third privately operated television channel, to be brought into service probably during 1986.

New Zealanders are avid watchers of television. According to a 1982 survey, New Zealanders spend on average 20 hours every week watching television (3).

Another information service widely available in New Zealand is the public library service. There are over 140 public lending libraries operated by local authorities throughout the country. These libraries offer a free lending service to the public. The education system also places considerable emphasis on the role of library services and encourages participation by school children from the early age of five.

Thus most New Zealanders have available to them an abundance of free or nearly free information services. In the business environment, there is a growing awareness of the value of information and we are now seeing a small number of consultants getting established in this area. With the development of videotex has emerged a new group of people who are best described as information brokers or information packagers. Their job is to understand the information needs of a particular industry group or individual client and select from the many sources available the information that is most relevant. In New Zealand, we are not short of information. In fact I suspect that like most other developed countries, we have too much information. The challenge facing us in the information age is how to filter the information that is most useful in dealing with a particular situation.

4. Videotex Development

Videotex was formally launched in New Zealand on 28 May 1984 with the commissioning of Post Office videotex access switches in Wellington and Auckland. These switches enable users to access videotex services from virtually any of the 2 million telephones in the country.

Discussions on videotex, however, started almost five years ago. In August of 1980, the Communications Advisory Council, a Government advisory body, published a report on Viewdata* in New Zealand (4). In this report the Council recommended that a system similar to the Bildschirmtext system being established at the time in West Germany would be most suited to the New Zealand environment.

Bildschirmtext was a development of the British Prestel system that introduced the concept of "gateway" services. Gateway services expanded the size of videotex beyond centralised general purpose databases to include the many hundreds of existing specialised databases. The role of the gateway is to provide access to and convert information contained in the external database into a format intelligible to a videotex terminal.

In July of 1982, Government gave the green light to the establishment of small scale videotex services, based on the "gateway" concept. The Post Office would provide the access network while anyone who wished could set up and operate a videotex database. Videotex was still very much at an evolutionary stage of development throughout the world but it was recognised that some first hand experience in New Zealand would both keep us up with the play and help identify market opportunities.

Following the July 1982 announcement, the Post Office convened a series of public meetings to discuss the question of standards; in May of 1983 a joint industry agreement was reached to embark on a two-year development period using systems based on either British Prestel or French Teletel. The objective of the meetings had been to select a single presentation layer standard, but with advocates of both the British and French systems taking an active part in the standards discussions it was impossible to reach agreement. The dual-standard decision was partly a "let the market decide" decision but also took into account the increasing availability of dual standard videotex products (terminals and database software). During the last 18 months, the trend towards multi-standard environments has continued with many videotex system suppliers now claiming support for more than one presentation layer protocol. For international interworking, the CCITT has, at least for the time being, agreed on three world systems - North American NAPLPS, European CEPT and Japanese CAPTAIN. During the next Plenary Period (1985 - 1988) efforts will be made to define a fourth syntax for international interworking, known as WWUVS (World Wide Unified Videotex Syntax). However, it is quite clear that videotex developments will continue along separate paths for some years yet and the multi-standard development strategy adopted by New Zealand will help ensure that we are well placed to take advantage of future developments.

By November 1984, 7 systems using the Prestel approach and 1 using Teletel were established, either as trials or full commercial services. All but a few of the 600 terminals in use at this time were Prestel terminals.

5. Videotex Services

5.1 Development Strategy

It has been evident for some time from the many videotex trials throughout the world that a videotex service, to be successful, requires a steady flow of revenue to sustain the system and ensure that stored information is regularly refreshed and kept up to date. To provide this revenue, videotex must offer a service that meets some clear cut user need and provides a direct and preferably quantifiable (in dollar terms) user benefit.

In New Zealand, therefore, initial videotex services are being shaped to meet the needs of particular user groups, e.g. farmers, veterinarians, travel agents, retailers, banks and others involved in the money market. The services currently being offered are discussed below.

5.2 New Zealand Post Office

The Post Office is developing a nationwide "store and retrieve" messaging service as an extension of existing telex and datex messaging services. Consideration is also being given to the possibility of establishing a public sector database.

5.3 Datacom Systems Limited

Datacom,one of New Zealand's largest computer bureaus, is providing a closed user group service called Vetlink for veterinarians and a stock management system for Fisher and Paykel whiteware dealers.

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*The term viewdata was originally used in New Zealand, but as in most other countries, videotex has now been adopted as the generic term for two-way interactive information services.

Vetlink includes diagnostic information, methods of treatment, details of animal remedies and rapid delivery of laboratory reports on analysis of samples. The existing database includes over 4000 pages of reference material. Vetlink is administered by a board which includes representatives of the Veterinary Association, the Veterinary Services Council, Wellcome NZ Ltd and the Bureau of Primary Information.

The Fisher and Paykel system provides dealers with a variety of services including the placement of orders, inquiry facilities enabling dealers to check the status of their orders, hire purchase and rental calculations, contract inquiry facilities, stock and sales information, promotion details and a spare parts order and inquiry system.

Both Vetlink and the Fisher and Paykel system use Datacom's Digital VAX 11750 machine.

5.4 IBM (NZ) Limited

IBM is developing a database listing of its own products and services.

5.5 ICL Bulletin

International Computers (NZ) Ltd is providing closed user group services to at least 4 organisations - Thomas Cook travel agents, the Bank of New Zealand, GUS retailers and the Auckland Electric Power Board.

Thomas Cook travel agents throughout the country have immediate access to information on foreign exchange rates, booking densities and package tour itineraries.

The Bank of New Zealand FOREX service provides up-to-date information on foreign exchange markets for its corporate clients.

The GUS Wholesalers Co-operative Society is planning to provide a stock information system for Value-Rite retailers in the South Island and lower half of the North Island. Retailers will be able to call up pages of information about products stocked in GUS warehouses, including the price, description and quantity held of each product.

The Auckland Electric Power Board is using videotex in a load management trial. Peak load information, which can vary rapidly, is being entered in the system and is immediately available to a number of large industrial users of electricity. This enables these users to take advantage of concessional electricity tariffs by reducing their demand during peak load periods.

All 4 services are provided from ICL's host computer (an ICL ME 29) in Auckland.

5.6 BPI Systems Limited

BPI Systems, a new company that has emerged with the development of videotex, is offering a range of business and farming information on its Aditel service. Initially targetted at farmers and the agricultural business community, information its available on farm finance, farm machinery, pasture management, pest and weed control, stock health and hard improvement. BPI has recently broadened its database to provide business services, including sharemarket reports, financial services and investment opportunities. It has also recently added a home shopping service, called Direct Shopper, which offers direct ordering of electrical goods and liquor products.

BPI operate their own host computer (a GEC 4160) but view their primary role as an information broker. In this role they match the information needs of selected user groups with the best sources of information available. Subscriptions to Aditel cost $270 per year. This includes 6 hours of access time every 2 months; additional access time costs 17 cents a minute.

5.7 Databank Systems

Databank provides computer facilities for the major trading banks and cheque clearing facilities for most of New Zealand's financial institutions. As an extension of these services Databank is planning to offer a range of financial and banking services using videotex. Home banking services are of special interest.

5.8 Telematics (NZ) Limited

Telematics another company that has emerged with the development of videotex, is proposing to set up a 6 month videotex trial for about 80 dairy farmers in the centre of the North Island.

5.9 NZI Finance Limited

NZI Finance, one of New Zealand's major finance houses, is planning to offer a commercial and financial news service.

5.10 Development Finance Corporation (DFC)

The DFC, a large Government owned corporation providing finance for development projects, has introduced a business information service called Vantage for its corporate clients. The service includes foreign exchange rates, money market rates, market commentaries, sharemarket prices and commentaries, economic indicators as well as Australian and United States business information. The database includes 2 business newsletters - Trans Tasman and New Zealand Economic News. The service is provided as a closed user group on Datacom's host computer in Wellington. User subscriptions are currently $150 per month.

DFC has also established a transactional service called Folio. It offers home banking, teleshopping, and a stocks and share buy and sell service. At present set up on a pilot basis, Folio is provided from ICL's Bulletin bureau.

6. Teletext Development

Teletext services were introduced in New Zealand at the beginning of 1984 and approximately 400 pages of information are currently being broadcast on both television channels using spare lines in the vertical blanking interval. Television New Zealand, which operates the two channels, has overall editorial rights and collates about half of the pages to provide items of news, information and entertainment. The remaining pages are prepared by the Disabled Persons Assembly (New Zealand) Inc. The Assembly co-ordinates input from organisations representing a range of disabled persons. Teletext is also used to provide programme captioning for the deaf.

The driving force for the development of teletext in New Zealand came primarily from the organisations responsible for disabled people. Initial funding was provided from a Telethon grant. This has been a good example of a clear community need being satisfied with new information technology. The less well defined need of information services for the general public has been a secondary development. These public services have followed conventional teletext developments, i.e. news headlines, weather forecasts, sports results, etc.

Planning is now in hand to provide direct links with Air New Zealand for flight arrival and departure information and the Totalisator Agency Board (TAB) for race results. The driving force for both these developments is an economic one. In the case of Air New Zealand, the high cost of providing a staffed flight enquiry service is stimulating the development of an electronic alternative. In the case of the TAB, the quicker race results can be returned to punters, the more likely they will be to place further bets.

7. Other Information Services

7.1 Local Databases

There are numerous other databases in New Zealand, but for the most part these are highly specialised and are of little commercial interest outside the organisations that have created them (5). Most of these are bibliographic databases containing citations and/or abstracts of printed literature such as journal articles, reports, books, newspaper articles. A few contain numeric information such as statistical or survey data. Two of the larger databases in the public domain are INFOS and NZBN. These are discussed below.

7.2 INFOS

INFOS is an information network for official statistics, developed and operated by the Department of Statistics.

It contains 300 000 statistical series and is the most comprehensive collection of statistical information on-line in New Zealand. There are approximately 200 registered users from 44 different organisations.

INFOS is more than a simple information retrieval system; users also have access to analytical tools, enabling them to manipulate data and even to set up their own private database on the system.

The host computer is an IBM 4331; the communication protocols are either bi-synchronous or SNA/SDLC. Access today is therefore restricted to users with IBM full screen 3270 type terminals. The potential user group is believed to be much wider and consideration is therefore being given to extending the availability of INFOS using the Post Office's recently introduced Packet Switching Service.

7.3 NZBN

The New Zealand Bibliographic Network (NZBN) is an on-line computer system which will eventually link most public, university and government department libraries in New Zealand (6). NZBN's primary function is shared cataloguing to eliminate the duplication of original cataloguing. However, the system has the potential to support a wide range of library services such as reference searches, bibliographic verification and holdings information, book acquisitions and interlibrary loans.

NZBN became operational within the National Library in September, 1982 and late last year the Wellington Public Library and the Victoria University Library joined the network. By the end of this year, it is expected that a further 24 libraries will have joined the system.

The system currently operates on a 4Gb Facom M180 machine but in March of this year will be transferred to an IBM 4341. SNA protocols are used for communicating with remote IBM 3270 type terminals. Because of the relatively high cost in New Zealand of such a terminal and communications controller (between $10,000 and $12,000) there has been some criticism that small libraries are likely to be excluded on the grounds of cost (7). Like the INFOS network, more flexible terminal arrangements with packet switching links to the central host computer could help extend the reach of the network.

7.4 OASIS

OASIS (Overseas Access Service for Information Systems) is a service offered by the Post Office since 1979, providing New Zealand users with low cost access to overseas databases. The service provided a dial-up 300 bit/sec data link to North America, Australia and Europe using multiplexed international voice grade circuits terminating on the respective national packet switching networks. OASIS has made the world's databases available to New Zealand users at an affordable price. The number of users has grown steadily from 7 in September 1979 to 282 in August 1984. The main users have been libraries, research institutions, banks and major companies.

With the establishment of the New Zealand Packet Switching Service in August 1984, the need for a special service such as OASIS has disappeared. Since August, all OASIS users have been allocated a network user identity (NUI) on the Packet Switching Service. International database connections are now made by simply entering the network user address (NUA) of the required host computer. The international packet switching charges for calls from New Zealand are as follows:

	Per Kilosegment	Per connect hour
To Australia	$6.00	$6.00
To all other countries	$12.00	$12.00

Users will therefore benefit from an even lower cost international service.

The databases most frequently accessed from New Zealand include Dialog, and Orbit in the USA, Diane in Europe and Eurolex in the United Kingdom.

8. Future Directions

8.1 Technology and People

Although New Zealand's entry into the electronic information marketplace has been fairly recent, some clear directions for future developments are already evident. These directions relate to both the technology required to deliver the information services as well as the structures and people required to make best use of the services.

8.2 Videotex Network Development

The existing videotex access service is provided using specially developed access units and the public switched telephone network (PSTN). A 6 digit local number is used in Wellington and Auckland where the initial access units are located; access from all other centres is obtained by dialling a Freefone number or in non-STD areas by asking the operator for a videotex call.

The videotex access unit comprises a number of auto answer modems (each providing a single terminal port) linked to a local microprocessor which controls the various functions of the access unit, e.g., terminal identification, presentation of database menu.

When a user selects a particular service from the access unit menu, a connection is automatically set up to the required host computer. This link is initially being provided using the PSTN but later this year will be replaced by the packet switching network.

Use of the packet switching network as the basic data transport mechanism will help ensure that videotex communication charges are kept as low as possible (existing communication charges are a flat rate charge of 8 cents per minute, independent of distance within New Zealand).

The use of the packet switching network also allows database operators to take advantage of the multiple virtual channel facility of X.25 connections.

8.3 Videotex Standards Development

All but one of the eight videotex services currently available use the British Prestel standard. The dominance of Prestel systems in New Zealand at this stage is not surprising given its dominant position on the world market. With more than 10 years of videotex experience in the United Kingdom pioneers like GEC Computers and ICL have been quick to secure a share of the New Zealand market.

However, the standards debate is by no means over. Support for the North American standard has grown significantly during the last 12 months to the extent that the Post Office is now planning to support NAPLPS terminals on its Videotex Access Service later this year.

There is also clear evidence from developments in other countries that at least some of the videotex market can best be served by standard text-only ASCII terminals.

The Post Office is committed to support Prestel and Teletel systems for the duration of the

2-year development period. Beyond that, it is likely that this support will extend to both NAPLPS and ASCII systems.

8.4 User Terminals

With the growth in electronic information services there is a corresponding growth in the range and variety of terminal devices becoming available to deliver the services. For videotex alone, there are four types of terminal product emerging in New Zealand.

Television set adaptors, dedicated business terminals, microcomputers with a videotex option and integrated business workstations.

Most videotex terminals in use today in New Zealand are of the first type, i.e., an adaptor requiring a separate television receiver as the display device. However the position is likely to change in the future. In the business environment, where most of the services are being targetted, the use of a domestic television receiver is not the most convenient. Dedicated business terminals could find a slot in this market, but they too are likely to have a limited life. Business executives do not want their desks cluttered with single function terminals.

Microcomputers and integrated business workstations are likely to eventually dominate the videotex terminal market in New Zealand. Already plug-in or add-on cards are becoming available for many of the popular microcomputers available in New Zealand (e.g., Sinclair Spectrum, Commodore 64, IBM PC, Apple IIE, BBC). Videotex then assumes a role of just one of the many services available on the microcomputer.

Business workstations which combine the functions of a telephone and a computer terminal are also emerging with built-in videotex facilities. Again the terminal is a multi-function unit, where videotex is just one of the services available.

These microcomputer and workstation developments help to underline the true role of videotex - as an information service, not a piece of hardware sitting on someone's desk.

8.5 Few Limitations on Use

Interactive information services such as videotex are available from virtually any telephone connection in the country. The only restriction is for party-line subscribers.

If a party-line is being used for a data service such as videotex and the other party picks up the telephone receiver to attempt to make a call the data call will automatically clear down. Such interference would be unacceptable to users.

However, the problem is progressively being resolved in New Zealand as telephone party subscribers throughout the country are being upgraded to individual service. Massive amounts of capital are being spent by the Post Office to complete this upgrading. As a result of this effort there will be very few party line subscribers left in the network in 5 years time.

8.6 Users will Become Information Providers

The unique characteristic of videotex as an information service is its two-way capability. This could eventually lead to a blurring of the boundaries between the information user and the information provider. Videotex makes it possible for every user to become an information provider, to enter information in the system and potentially obtain revenue from other's use of that information.

Early videotex systems, which were driven largely by available technology and its cost, failed to recognise this potential. The early Prestel and Teletel systems, which are being used in New Zealand, opted for the use of a terminal modem which does not allow the full two-way potential to be realised. The transmission speeds used with today's Prestel and Teletel systems are 1200 bits per second from the videotex database to the user terminal and 75 bits per second from the terminal to the database. While 75 bits per second is more than adequate for a menu selection command or for completing an order form, it does not allow users to create a series of videotex pages and load them into a central database, e.g., for transferring a user-written computer program (telesoftware).

North American videotex systems evolved more recently and were able to take advantage of reducing modem prices to use a transmission speed of 1200 bits per second in both directions.

Even more recent developments suggest that even 1200 bits per second is too limiting. For example, at this speed, it takes over 1 minute to build up a picture occupying only 1/9th of the screen. For high resolution graphics and picture videotex, the coming digital networks with a two-way 64,000 bits per second transmission path may provide the solution.

8.7 New Information Centres will Evolve

Emphasis is frequently given to the user-friendly characteristic of videotex and how videotex will be the "average" person's entry to the computer world. While there may be an element of truth in this, the full potential of videotex is unlikely to be realised for many without the aid of some intermediate assistance. It is easy to become disillusioned after 2 or 3 attempts in a tree-structured database fail to locate the information required; without previous experience it is not immediately evident whether the fault lies with the user (wrong tree branch selected) or the information provider (information not in fact in the database).

To overcome this problem an information service agent is required; someone who can interpret our needs and use the videotex service in an efficient manner to assist us in finding the information required.

Historically, the information service agent has played an important role in our society, although we tend to call them something different such as librarians, training officers, real estate agents, travel agents, farm advisors, public relations officers, etc. There is no reason to suspect that all these people are going to disappear overnight. In fact, in New Zealand they are amongst the first to use videotex. Videotex however could change the structures of established information centres. It allows much greater decentralisation of the "centres". The new information centres could be as portable as a briefcase or become an adjunct to some other natural meeting place, such as the coffee shop or the corner dairy. Videotex does not need to automatically lead to a greater depersonalising and isolation within our society; it has the potential to help us maintain and even rekindle the way of life we most value.

8.8 Advertising Support will be Important

The presentation of information services on videotex presents new marketing and advertising challenges. Consumers will still require goods and services; the challenge for the suppliers will be how best to make use of this new medium to inform and persuade. Unlike television, there will be no predictable size of audience captive at any point in time. But on the other hand, videotex will provide advertisers with well defined groups of users. This will allow more targetted advertising than the broader approach of the traditional media (newspapers, radio and television).

Videotex also has the potential to develop and store user profiles or user interest patterns. These could be automatically generated by each system operator, based on the types of information accessed, but the sale of these profiles to advertisers could present some privacy problems. However, in a more positive light users may willingly enter interest profiles into the system so that they can be automatically notified whenever a particular type of product becomes available. Thus videotex has some benefits for advertisers which is just as well, since videotex will need advertising dollars to help establish and maintain dynamic databases. Like other media, without advertising support, the cost of the end product whether it be a newspaper, specialist journal or a television programme, the direct cost to the consumer would be prohibitive. While a videotex service provider's overheads may not be as high as a newspaper publisher or a television network, the cost of this end of the videotex business should not be underestimated. Costs include the provision of a host computer and support services, communication links to the Videotex Access Service, system software and its maintenance, page creation and updating (which alone can be as high as $50 per frame) as well as promotion costs.

There is little doubt, therefore, that videotex needs advertising support. Videotex operators must therefore give due consideration to the needs of advertisers in establishing their systems.

8.9 Videotex Packages Require One Indispensible Service

Videotex, like some other new services which rely on co-operative efforts between a number of component suppliers, suffers from the classic chicken and egg problem. The version of this problem relevant to our New Zealand environment hinges on a potential user's decision to take out a subscription to a service (or just as important in these early days, the decision to renew an existing subscription).

Before taking out a subscription, a potential user needs to be persuaded that the service will meet some unsatisfied need. On the other hand a system operator requires substantial capital to not only establish a service but also maintain it; an early flow of revenue from subscribers is therefore critical for both survival and further development.

Early experience throughout the world has already shown that videotex operators who expect to sell a service based on the size of their database alone will be sorely disappointed. Targetted information services, as are being developed in New Zealand, help in cracking the chicken and egg problem. But an even more certain solution is to provide for every user at least one "indispensible" service, a service which provides some immediate and preferably monetary benefit to the user. For some users, regularly updated sharemarket information would fit this category; for others a home banking service would suffice.

Having identified such a service, a package of other services can be included to stimulate sales. This is the formula adopted by the Homelink and Micronet services in the United Kingdom, and according to all reports, has succeeded where earlier less directed marketing approaches have failed.

9. Conclusion

New Zealand's information services are on a well defined development path. Videotex and other electronic database services have emerged in response to well defined user needs and are therefore well founded for future growth.

Videotex in particular has developed as a co-operative effort, between computer suppliers, computer bureaus, terminal suppliers, information providers, the Post Office as the supplier of communication services and the new breed of people, information brokers or packagers.

New Zealand has a history of similar successful partnerships between public and private sector interests; videotex is well placed to continue this tradition.

Nevertheless, care must be taken not to become over optimistic about the role of videotex. Relative to other countries the total market in New Zealand is very small. However with the rapid growth of international communications, in particular international packet switching, countries such as New Zealand can look to overseas markets to sustain and assist with the development of new information services. It is essential therefore that national networks and services develop in concert with the international scene. Only then can we be assured that videotex and related information services will in fact grow to be as pervasive in the future as the telephone is today.

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Digitalization of Japan's International Networks

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Abstract

Digitalization of the international networks is being undertaken in Japan. Digital transmission links will be implemented by means of digital satellite communication systems and optical fiber submarine cables. Digital switching systems are also being implemented at INTS. This is a very essential step to pave the way toward the ISDN which is regarded as an ultimate goal of network evolution.

1. Introduction

In recent years, use of international telecommunication has shown rapid growth in total traffic volume together with remarkable change in the way of using telecommunication services. To cope with the growth and the change, expansion of international telephone networks is in progress, and furthermore implementation of new non-voice networks is being undertaken for such services as facsimile, packet switched data, circuit-switched data, etc.

Provision of services by individual networks, however, is considered not economical, because implementation cost as well as operation and maintenance cost would be proportional to the number of provided services. Service integration is desirable for this reason, and the concept of the Integrated Service Digital Network (ISDN), where a variety of services are provided by a single network is under study in CCITT.

In order to realize the ISDN, the first step is digitalization of networks because end-to-end digital connections provided by digitalized networks are essential factor to commonly offer variety of services.

KDD is promoting digitalization of international transmission links and switching equipment, bearing an ultimate goal of ISDN in mind. This paper presents the plan of digitalization of Japan's international network together with the plan of network integration toward ISDN.

2. Digitalization of international transmission links

(1) Satellite links

(a) TDMA/DSI

KDD is utilizing INTELSAT satellites as major means of international links, and is operating two earth stations; Ibaraki for Pacific Ocean Region (POR) and Yamaguchi for Indian Ocean Region (IOR). In the IOR, it is scheduled to introduce TDMA/DSI (Time Division Multiple Access/Digital Speech Interpolation) in the second half of 1985. KDD will join in the operation of the TDMA/DSI from the beginning, and will establish digital links with seven countries in Europe. Table 1 shows major parameters of the TDMA/DSI system, and Table 2 shows the implementation schedule of the system.

The TDMA/DSI system can provide not only digital telephone links but also digital data links. TDMA signals transmitted from earth stations comprises the DSI portion and the DNI (Digital Non-Interpolation) portion. The DSI portion is to be used for public switched telephone networks, while the DNI portion is for data links such as public data networks and leased data circuits. Data links up to about 6 Mbps can be provided by using the DNI portion.

According to the INTELSAT specification of the TDMA/DSI system, the PCM coding scheme of A-law is to be used as a standard. Therefore A-law to u-law conversion is needed in Japan. KDD performs the A/u conversion at Yamaguchi earth station for the time being in order to ease the back-up of the TDMA carriers by FDM/FM carriers. In near future, A/u conversion will be performed at the telephone gateway office.

The clock of the INTELSAT TDMA/DSI system is controlled by the Reference stations in the system. Plesiochronous connection is used to absorb the difference of clock frequencies between national digital networks and the INTELSAT TDMA/DSI system. Daily variation of the clock frequency due to relative movement of the satellite, or Doppler shift, has also to be compensated by memories of length enough to absorb the Doppler shift. These functions to absorb the difference of the clock frequencies and the variation due to the Doppler shift will be located at Yamaguchi earth station.

(b) IDR Carriers

Recently, INTELSAT has decided to introduce a new standard of digital modulation, which is called as IDR (Intermediate Data Rate) carriers. This new standard is an extended application of SCPC to higher bit rate (up to 44 Mbps) digital transmission. It should be noted that SCPC could be used for digital transmission up to 64 kbps.

The IDR carriers are permitted to use for the public switched telephone networks as well as for data links. Carrier sizes and performances are shown in Table 3.

KDD has been studying the use of the IDR carriers in the POR rather than TDMA/DSI in order to establish digital links for telephone networks. IDR carriers are very cost effective means to provide digital links with a small number of countries, since they do not require the Reference Stations and TDMA functions.

In the POR, there are a small number of heavy traffic routes as compared to other Ocean Regions. Therefore, IDR carriers may be more suited than the TDMA/DSI system at an early stage. When the number of participating earth stations become large enough for the TDMA cost to outweigh the cost of multi-carrier operation, provision of digital links in the POR will be transferred from IDR carriers to the TDMA/DSI system.

KDD is considering to build a 14/11 GHz earth station in 1987 at a location near the new international telecommunication center at Oyama. This new Standard C station will be used to operate IDR carriers to establish digital links for the telephone and data networks with countries in the POR. The Digital Circuit Multiplication [see 2(a)(iii)] may be applied to IDR carriers.

TABLE 1 SYSTEM PARAMETERS OF INTELSAT TDMA SYSTEM

PCM CODING		CCITT REC. G711 (8kHz SAMPLING, 8-BIT CODING, A-LAW COMPANDING)
MODULATION		4-PHASE PSK MODULATION (ABSOLUTE CODING)
DEMODULATION		COHERENT DETECTION
BIT RATE		120.832 M BIT/S
SYMBOL RATE		60.416 M BAUDS 1 SYMBOL: 16.6 nsec
FEC CODING		(128, 112) BCH CODE: DOUBLE ERROR CORRECTION, TRIPLE ERROR DETECTION APPLIED TO BURSTS SPECIFIED BY INTELSAT
TDMA FRAME LENGTH		2 msec
MULTIFRAME LENGTH		16 TDMA FRAMES = 32 msec
NUMBER OF REFERENCE BURSTS		2 REFERENCE BURSTS/TDMA FRAME
DSI	NUMBER OF INPUT TERRESTRIAL CHANNELS	MINIMUM 1, MAXIMUM 240 CAN BE INCREASED/DECREASED BY ONE CHANNEL
	NUMBER OF SATELLITE CHANNELS	MINIMUM 1, MAXIMUM 127 CAN BE INCREASED/DECREASED BY ONE CHANNEL
	NUMBER OF DESTINATIONS	Maximum 8 (SINGLE DESTINATION DSI IS AVAILABLE AT APPROVAL BY INTELSAT)
	NUMBER OF OVERLOAD SATELLITE CHANNELS	MAXIMUM 16
	PREASSIGNED NON-INTERPOLATED CHANNELS	SOME OR ALL SATELLITE CHANNELS OF A DSI SUB-BURST CAN BE PREASSIGNED FOR NON-INTERPOLATED OPERATION.

TABLE 2 TDMA IMPLEMENTATION SCHEDULE IN IOR

1985		1986	1987
AUSTRALIA	KOREA	PHILIPPINES	MALAYSIA
FRANCE	NETHERLANDS	THAILAND	CHINA
HONG KONG	GERMANY	TAIWAN	TURKEY
INDONESIA	INDIA	GREECE	
JAPAN	ITALY	PAKISTAN	
U.K.	SINGAPORE	SPAIN	

TABLE 3 INTERMEDIATE DATA RATE (IDR) CARRIERS

INFORMATION RATE	APPLICATIONS (EXAMPLES)	BIT ERROR RATE	MODULATION	EARTH STATIONS
64 KBPS │ 44.736 MBPS	- DATA - FACSIMILE - VOICE - VIDEO FOR TELECONFERENCES - HIGH SPEED DATA TRANSFER - PUBLIC SWITCHED TELEPHONE	IN ACCORDANCE WITH CCIR REC. 522-1 1×10^{-6} (20% OF ANY MONTH) 1×10^{-4} (0.3% OF ANY MONTH) 1×10^{-3} (0.01% OF ANY YEAR) WITHOUT FEC	QPSK/FDMA USING SCPC OR MULTIPLE CHANNEL PER CARRIER	STANDARD A STANDARD B STANDARD C

TABLE 4 INTELSAT BUSINESS SERVICES (IBS)

INFORMATION RATE		APPLICATIONS (EXAMPLES)	BIT ERROR RATE	MODULATION	EARTH STATIONS
LOW-MEDIUM	64, 128, 256, 384, 512, 768 KBPS	- DATA PATH - FACSIMILE - VOICE	1×10^{-6} FOR 99% OF THE YEAR WITH 3/4 FEC	- QPSK/FDMA USING SCPC OR MULTIPLE CHANNEL-PER-CARRIER - TDMA ON A CASE-BY-CASE BASIS	14/11 OR 14/12 GHz BANDS STANDARD E-1 3.5m E-2 5.5m E-3 8.0m STANDARD C 6/4 GHz BANDS STANDARD F-1 5.0m F-2 7.0m F-3 9.0m STANDARD A OR B
HIGH	1.544 2.048 4.096 6.312 8.448 MBPS	- FULL MOTION COLOR VIDEO FOR TELE-CONFERENCES - HIGH SPEED DATA TRANSFER - MULTIPLEXED SERVICE			

(c) IBS

INTELSAT has begun to offer the INTELSAT business service (IBS) since October 1983. This service is a totally digital integrated service to permit the provision of the full range of business service applications. It will introduce digital transmission services with speeds of 64, 128, 256, 384, 512, 768, 1544, 2048 and 8448 kbps. Error performance and earth stations to be used are shown in Table 4.

KDD is considering to utilize the IBS for digital links to offer high speed data, high speed facsimile and teleconference services. Country gateway earth stations should be used to provide the services in the IOR due to the constraint of the satellite coverage, and also at an earlier stage in the POR due to the constraint of interference from terrestrial microwave links.

In the POR, however, use of urban gateway earth stations will become possible at a later date when the INTELSAT satellite with the IBS package of 14/12 GHz bands becomes available. Use of 14/12 GHz bands will be able to eliminate the problem of interference from terrestrial microwave links. High speed digital services such as 1.5 Mbps would be more economical when they are provided through urban gateway earth stations.

(2) Submarine Cables

(a) HAW-4/TPC-3

(i) Construction plan

Construction of an optical fiber submarine cable is planned in the Pacific Ocean Region. This cable (HAW-4/TPC-3), which will connect U.S. and Japan, is scheduled to be put into operation in 1988.

The SL system and the OS-280M system, which are the optical fiber submarine cable systems developed in U.S. and Japan, respectively, will be used for the HAW-4/TPC-3. The OS-280M system consists of two single-mode fiber pairs, each driven by a 1.3 um laser diode operating at 295.6 Mbps, thus resulting in a maximum transmission capacity (both way) of 560 Mbps. Design parameters of the OS-280M system are shown in Table-5.

When the HAW-4/TPC-3 is put into operation, 140 Mbps digital line sections which meet CCITT standards will become available between U.S. and Japan.

(ii) Interworking hierarchy

Digital hierarchies to be employed in the HAW-4/TPC-3 will be those recommended by the CCITT (G.802) as the international interworking hierarchies between networks using different digital hierarchies, namely 2-6-45-140 Mbit/s. Other primary levels, e.g. 1.5 Mbit/s may alternatively be employed. The second level, 6 Mbit/s will be composed of either three 2 Mbit/s signals or four 1.5 Mbit/s signals. With this interworking arrangement, national networks with 1.5 Mbit/s primary level, such as in Japan and U.S., will be able to offer the transparency for 2 Mbit/s signals.

KDD has a plan to develop new digital muldexes to be used for TPC-3. These muldexes are expected to incorporate the frame structures for 2-6 Mbit/s and 45-140 Mbit/s multiplexing which conform to the specifications to be adopted in the CCITT inter-regnum forum.

TABLE 5 DESIGN PARAMETERS OF OS-280M

TRANSMISSION BIT RATE	295.6 MBPS
TRANSMISSION CAPACITY (PER PAIR OF FIBER)	3780 CIRCUITS (64 KB/S)
NUMBER OF FIBERS	2 PAIRS
MAXIMUM SYSTEM LENGTH	8000 km
MAXIMUM SEA DEPTH	8000 m
FIBER LOSS	0.45 dB/km
BIT ERROR RATE	LESS THAN 10^{-8}
REPEATER SPAN	50 km
DESIGN LITE	25 YEARS
CROSS SECTION OF THE CABLE	FIG. 1

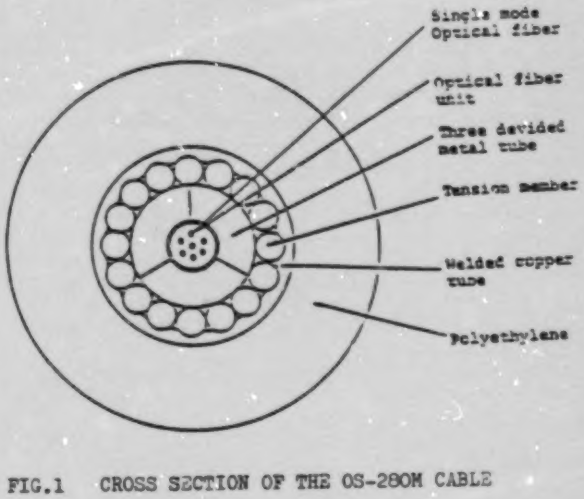

FIG.1 CROSS SECTION OF THE OS-280M CABLE

(iii) Digital Circuit Multiplexing (DCM)

In the HAW-4/TPC-3, digital circuit multiplexing (DCM) technique will be employed to effectively utilize the capacity of the cable systems. The DCM employs the 32 kbit/s ADPCM encoding together with DSI, thereby increasing the cable capacity about five times as compared to that of 64 kbit/s PCM encoding.

With regard to the 32 kbit/s ADPCM encoding, a new recommendation (G.721) was adopted at the CCITT Plenary Assembly in October, 1984. The recommended encoding alogorithm can gurantee the transparency of voiceband data signals at up to 4.8 kbit/s. Measurement on international data traffic through the public switched telephone network, however, revealed that more than 50 percent of voiceband data signals were operated at 7.2 or 9.6 kbit/s.(1)

In Japan, an advanced 32 kbit/s ADPCM encoding algorithm which can transmit the voiceband data with the speed of up to 9.6 kbit/s has already been implemented into hardware.(2)

Recognizing the importance of transparency to voiceband data pervailing in the telephone network, KDD has undertaken a development work of DCME for the TPC-3 which incorporates the advanced ADPCM. Development of the DCME will be completed before March, 1986.

(b) East Asia Optical Fiber Cables

Optical fiber submarine cables are also planned to be implementated in East Asia Region in 1990 to interconnect U.S., Korea, Philippines, Hong Kong, Taiwan and Japan. Cable routes [illegible] capacities are still under study. When construction of these cables is completed, 140 Mbit/s digital line section will become available among these countries.

3. Digitalization of the international telephone switching systems

(1) Implementation of digital telephone switching systems

Recently the traffic of international telephone to and from Japan has been increasingly growing at about 30 percent per year. Accelerating this trend, an increase of international subscriber dialing (ISD) traffic has raised the concentration ratio of the busy hour.

To cope with the rapid growth of international telephone traffic, KDD has decided to implement new international telephone switching systems (INTS) at Osaka and Oyama. The INTS at Osaka (XE-10) has started its operation in March, 1984. The INTS at Oyama (XE-20) is to be put into operation in September 1985. Another new INTS (XE-30) will be installed at Tokyo by the end of 1986.(3) Network configuration after the completion of these three INTS will be as shown in Fig. 2.

Digital type of exchange are employed for all of these new INTS for the following reasons:

1) Since digitalization of the domestic network is in progress, the INTS and the domestic gateway offices can directly be linked by digital multiplex transmission lines, thus resulting in economic efficiency by integration of transmission and switching.

2) The digital INTS can easily interconnect with the digitalized international transmission links.

3) The digital INTS are essential to implement the end-to-end digital network which eventually evolve to ISDN.

(2) Main features of the digital switching systems

Main features of the large-capacity digital switching systems implemented at Oyama (XE-10) and at Osaka (XE-20) are given in Table 6.

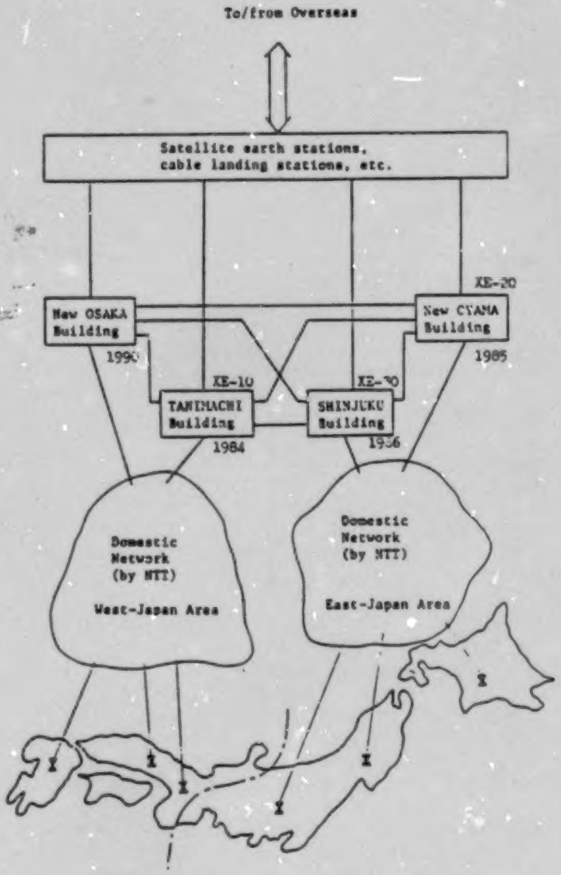

FIG.2 TELEPHONE NETWORK STRUCTURE

A highway with 132 time slots (128 channels switchable) at 8.448 Mbit/s is used as the transmission-switching interface, which is compatible with CCITT Recommendation G.796.

The u-law encoding law is used in the digital exchange systems. For circuits with CEPT countries, A-law to u-law conversion will be performed in the digital transmission interface equipment to be connected to the 8.448 Mbit/s highway.

The synchronization clock is supplied from the switching system itself when INTS is interfacing with analogue domestic transmission lines. In the near future, however, when INTS interfaces with the domestic digital network, the clock will be synchronized to the domestic network.

(3) Signalling systems

Current signalling systems for telephone switching include the CCITT No.5 signalling system and the CCITT No.6 signalling system, which are well suitable with electronic switching systems. KDD has been using these systems in the international telephone networks.

There are, however, some problems on these existing signalling systems such that they are designed only for telephone traffic and that switching capability has functional restriction.

To cope with this limitation, CCITT SGXI has been studying No.7 signalling system, which will easily allow end-to-end digital connection for variety of services i.e., service integration, paving the way to ISDN in the near future. An international field test of the new CCITT No.7 digital network signaling system was successfully conducted between KDD, Telecom Australia and OTC(A) in 1984.

As for the domestic telephone network in Japan, NTT has been introducing the domestic version of CCITT No.7 signalling into inter transit-switch circuits since March 1982.

Digitalization of circuits between INTS and NTT's switches is now going on and is expected to be completed by 1985. Hence, KDD is planning to introduce the domestic version of CCITT No.7 signalling into the circuits between INTS and NTT's switches in the near future.

KDD's digital switches have capability to implement CCITT No.7 signalling with possible software modifications.

Either Telephone User Part or ISDN User Part of the CCITT No.7 signalling system will be applied to the telephone service, taking account of progress of standardization of the No.7 signalling specification and of these application plans of other countries concerned bearing KDD's ISDN strategies and plans in mind.

TABLE 6 MAIN FEATURES OF THE XE-10/20 SYSTEMS

ITEM	SPECIFICATION
SYSTEM CAPACITY:	
• NUMBER OF TERMINATION	67,584
• CALL HANDLING CAPACITY (BHCA)	180,000 (XE-20), 90,000 (XE-10)
• NUMBER OF INTERNATIONAL CIRCUITS	10,000 (XE-20), 5,000 (XE-10)
• NUMBER OF SWITCHBOARDS	500
SIGNALLING SYSTEM FOR INTERNATIONAL	CCITT No.5, No.6
CONFIGURATION OF SPEECH PATH SWITCHING NETWORK	T-S-S-T (DUPLICATED) 512 MULTIPLEXING
DIGITAL TRANSMISSION INTERFACE	8.448Mbps $(120^{ch}/132^{TS})$ A/u CONVERTER (OPTION)
CENTRAL PROCESSOR FOR SUBSYSTEM	D 10 HCP (DUPLICATED)
SOFTWARE:	
• LANGUAGES	CHILL AND ASSEMBLY
• PROGRAM SCALE STEPS	685K (XE-20), 325K (XE-10)

4. Network integration toward ISDN

Digitalization of the international communication networks is the first stage of development toward ISDN, which will be followed by the second stage of the integration of non-telephone networks. The third and final stage will be the integration of the telephone network with data networks.

Detailed development at each stage are given below:

(1) Stage 1 - digitalization of individual networks

Stage 1 is the period when the individual service networks - including the telephone network - are progressively digitalized, and is expected to last for five to eight years. By about 1990, approximately 90% of KDD's communications facilities will have been completely digitalized. There may be some transmission links where the analog system remains in operation, for example, analogue submarine cables and a part of satellite links, but these will probably be dealt with by A/D conversion. In any case, switches and other equipment installed in the central office will all have been made digital.

In this stage, a number of new non-telephone services will be commenced to meet the demand for diversified communication services. KDD plans to start the circuit-switched public data service in 1986. Further, a study is being made for the facsimile transfer service by introducing the inter-network system designed to handle facsimile service. Provision of the satellite digital communication service for business application is also planned to commence in 1988. Enhanced message services such as the mail-box service are under consideration by using the technology of the message handling system (MHS).

(2) Stage 2 - progressive integration of non-telephone services

Stage 2, which will overlap with Stage 1 (~1990), is viewed as a period when non-voice applications of the telephone network develop further, and also integration of non-telephone type services - especially of data networks - is promoted.

KDD is to start the development work of the user-network interface system and the exchange system for ISDN, which enable service integration on the circuit-switched data network, providing users with 2B+D (64+64+16 kbit/s) interface in accordance with CCITT Rec. I. 412.

Service integration of subscriber lines and LS levels will be achieved first, then gradually proceed to TS level, and various interworking between ISDN in LS level and existing networks in TS level will be achieved. Stage 2 is expected to last for 10 years from 1985-1995.

Service integration in subscriber systems will give subscribers access to a network for several services (applications) on one subscriber line. It represents a great convenience to the user, and is the main objective of ISDN. ISDN subscriber lines utilizing paired cables, for example, with a transmission capacity of 64 + 64 + 16 (=144) kbps, can be used for almost all applications except video or the transmission of moving pictures for television.

(3) Stage 3 - integration of the telephone network with data networks

This final stage in the development of networks is the period when the telephone network and data networks are integrated, and fully-fledged ISDN makes their appearance. This integration will take place during the period from 1995 to the 21st century, i.e., more than 15 years from now, during which time existing network resources must be continually redeemed and digitalization encouraged.

Fig.3 summarizes the arguments so far, and shows how networks evolves toward ISDN in a stepwise fashion. The point to be emphasized most is

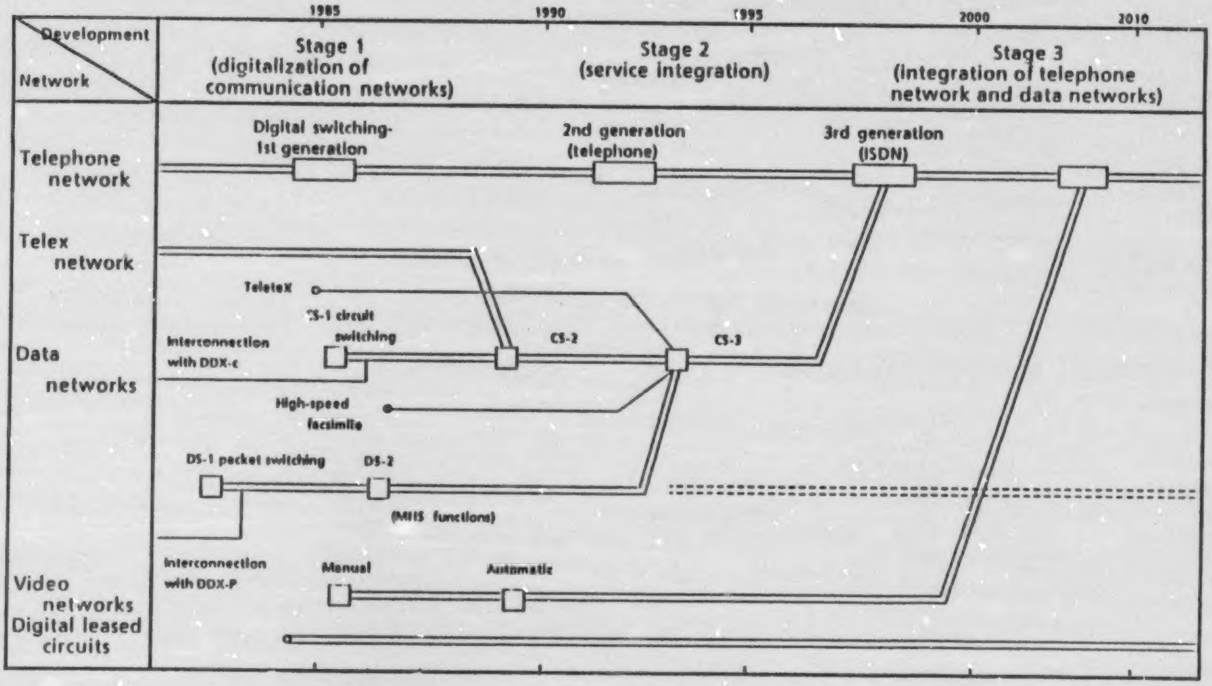
1985
1990
1995
2000
2010
Development
Network
Stage 1 (digitalization of communication networks)
Stage 2 (service integration)
Stage 3 (integration of telephone network and data networks)
Telephone network
Digital switching-1st generation
2nd generation (telephone)
3rd generation (ISDN)
Telex network
Data networks
TeleteX
CS-1 circuit switching
Interconnection with DDX-c
CS-2
CS-3
High-speed facsimile
DS-1 packet switching
DS-2
(MHS functions)
Interconnection with DDX-P
Video networks
Digital leased circuits
Manual
Automatic

FIG.3 OUTLINE OF SCENARIO TOWARD ISDN

that, in order to bring the advantage of digital transmission as early as possible to users of international communications awaiting non-voice applications, the non-telephone ISDN based on data networks should be implemented prior to the implementation of total ISDN, which will probably be completed by the 21st century. Circuit switching is more suitable than packet switching in adaptation for digital transmission and can handle a very high volume of traffic. It is thus assumed that as more digital transmission lines are constructed, circuit switching will be the main element in data networks.

Packet switching might probably continue to have a wide variety of application in uses where it is connected to data processing systems.

Video networks will for a considerable period be set up independently and separately from public networks such as telephone or data; and for the time being will continue to be operated manually by demand assignment. Although they will, no doubt, eventually be integrated into the total ISDN, this will probably come much later than the integration of the telephone network and data networks.

5. Conclusion

Implementation of digital networks which are able to provide end-to-end digital connections are an essential step to achieve the ISDN. KDD is positively undertaking the digitalization of the international communication networks. Digital transmission links will be provided by means of digital satellite communication systems and optical fiber submarine cables. Digital switching systems will be implemented at Oyama and Tokyo in addition to the one at Osaka.

Digitalization of networks is the first stage of network evolution toward ISDN, which will be followed by the stage of integration of non-telephone services. At the final stage, the telephone network will be integrated with data networks to reach the final goal, i.e., completion of the ISDN.

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(1) CCITT Contribution [1981-1984] COM XVIII-No.249

"Encoding of speech and voice-band signals using methods other than PCM"

(2) A. Fukasawa et al., "A 32 kbit/s ADPCM codec based on a new algorithm", Proc. GLOBCOM'83, 1983

(3) N. Baba et al., "A very large-scale digital international telephone switching systems", ISS'84 Florence, 7-11 May 1984

Digital Network for Facsimile Communications
- Facsimile Communications Network Service

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1. Abstract

For years, facsimile communications have grown remarkably in Japan. NTT has been providing an exclusive network service for facsimile communications called "Facsimile Communications Network Service (FCNS)" since 1981 corresponding with such demans of facsimile communications. The FCNS is the leading services of ISDN (called INS) which NTT is now promoting with emphasis. This paper first outlines the purposes of the FCNS, the major service of INS. It also describes current operation, including network configurations, service functions, charges etc. Finally, several applications of the facsimile network including investors information service, education service and retail business service are outlined.

2. Market conditions

In 1972, it became possible to implement facsimile services freely throughout the telephone network.
Thereafter, facsimile communication over the public switched telephone netweork (PSTN) increased rapidly, mainly because of business use but also because of technological progress. Facsimile terminals are standarized by CCITT and classfied as Group 1, Group 2 and Group 3 machines. Along with the MINIFAX, these terminal categories are the main ones in use. In recent years, Group 3 high speed terminals and MINIFAXs have showed remarkable growth as shown in Figure 1.
The backgrounds and reasons for such growth is considered as follows.

(1) Characters and graphics are able to be transmitted by facsimile. Therefore facsimile communications are suitable for the Japanese language which uses the "Kanji" and "Kana" scripts.

(2) Enhanced and economic facsimile terminals have been developed along with technological developments in electronics.

(3) Facsimile terminals have distinctive features such as accuracy, ease of handling, and the provision of hard-copy for more accurate record-keeping.

Almost all fascimile communications have been using the telephone network. This network is, of course, originally designed for voice communications, and is not always suitable for facsimile communications.
In addition, the charges are applied to facsimile communications on the same basis as for telephone tariffs which are expensive, especially for long distance communications.

NTT provided an exclusive network called the "Facsimile Communications Network Service (FCNS)" in September, 1981, for the purpose of upgrading economical and functional facsimile communications.

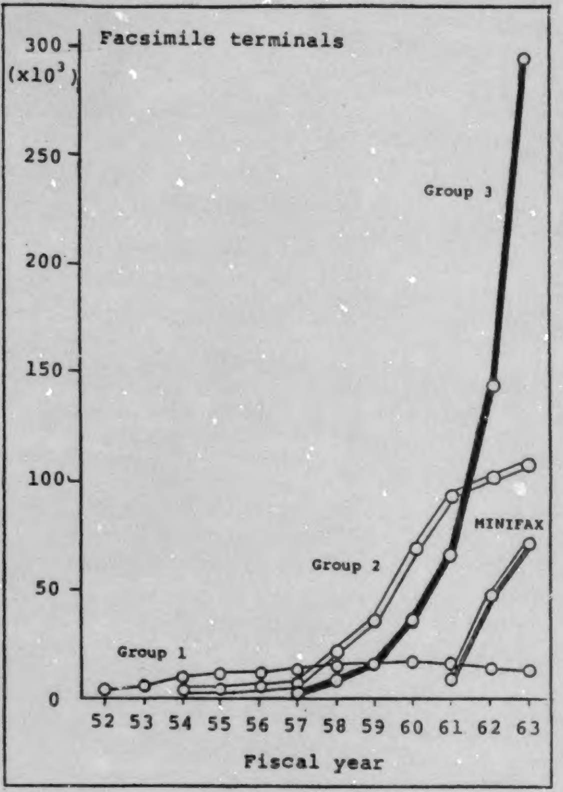

Figure 1
Facsimile terminal installation trend

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3. Outline of the FCNS

3.1 Purpose of the FCNS's development

Facsimile communications are an one-way transmission of information. Therefore it is effective to store the facsimile texts in the network temporarily and transmit them by high speed digital trunks afterward.
With this system (the store-and-forward configuration), the FCNS realizes high digital trunk efficiency and thus, relatively low-cost long-distance transmission. The FCNS is based on the following concepts.

(a) Some facsimile functions are centralized into network facilities in order to achieve low cost terminals.

(b) The storage and conversion function is adopted, whereby various fascimile services can be easily realized, and transmission channel efficiency has increased.

(c) The digital transmission system is applied to long-distance transmission channels.

(d) Existing network facilities are utilized as much as possible.

3.2 In order to meet the previously mentioned demands, the FCNS has adopted an improved system configuration considering the future shift to the ISDN.

(a) Facsimile Storage and Conversion Equipment (STOC) has been set up at a high network hierarchical stage in order to centraglize communication processing, e.g. storage and conversion. This equipment is suitable for providing long-term storage services.

(b) Facsimile Signal Conversion and Procedure Control Equipment (FCAP) has been developed in order to facilitate economical, digital transmission channels between STOCs and Toll-switches which are equipped with facsimile communication functions (TS-FX). This enables an economical expansion of the service area.

(c) Facsimile Data Conversion and Interface Control Equipment (FDIC) has been developed to allow a more convenient utilization of facsimile communications. This equipment provides media conversion functions such as conversion from facsimile signals to coded data and vice versa, and protocol conversion.
It provides communication services between computers and facsimile terminals, which are called center-end communication services.
Figure 2 illustrates the basic configurations for the FCNS.

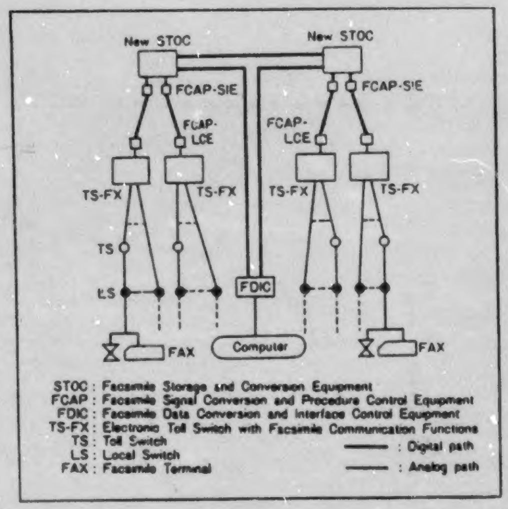

New STOC
New STOC
FCAP-SIE
FCAP-SIE
FCAP-LCE
FCAP-LCE
TS-FX
TS-FX
TS-FX
TS-FX
TS
LS
FDIC
FAX
Computer
FAX
STOC : Facsimile Storage and Conversion Equipment
FCAP : Facsimile Signal Conversion and Procedure Control Equipment
FDIC : Facsimile Data Conversion and Interface Control Equipment
TS-FX : Electronic Toll Switch with Facsimile Communication Functions
TS : Toll Switch
LS : Local Switch
FAX : Facsimile Terminal
: Digital path
: Analog path

Figure 2
FCNS basic network configuration

3.3 Service functions

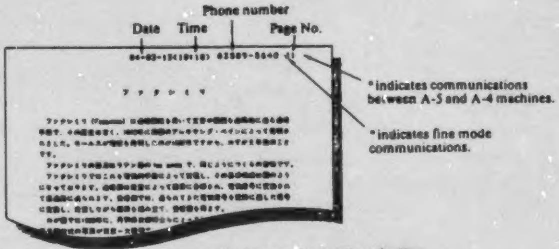
FCNS provides various sophisticated services. Its service functions are as follows.

(a) Automatic reception

Unattended facsimile reception that automatically switches the machine on and off is provided.

(b) Automatic recording of calling phone number and other information

The date and time of communication, calling phone number, and the serial number of pages are automatically recorded on the upper portion of the recording paper. This allows a customer to see who sent the message, and when, at a glance.


Phone number
Date
Time
Page No.
* indicates communications between A-5 and A-4 machines.
* indicates fine mode communications.

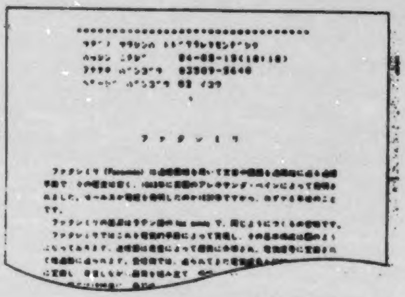
An example of automatic recording of calling phone number and other information

(c) Automatic redialing

Whenever a called number is busy, it is repeatedly redialed at a certain interval, for 30 minutes after the first call attempt, by the facsimile storage and conversion system (STOC). If the called party does not answer even after repeated redialing, an undelivered notice will be automatically sent to the calling party.

(d) Undelivered notice

The undelivered notice contains a brief message in Japanese, the transmission date and time, the called telephone number, the number of copy pages and all or part of the first page of the undelivered text.



An example of undelivered notice

(e) Abbreviated dialing

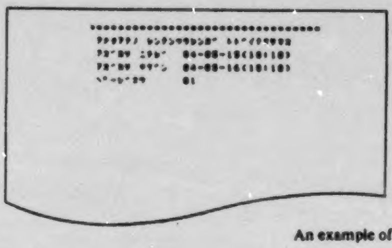
If a customer has a pushbutton phone and has registered with the NTT office for this service, he can program his phone to dial frequently-called numbers, by using a 2-digit code. This feature is available with either a 40- or 100-number capacity. This capacity is in addition to the capacity available for ordinary abbreviated dialing service for pushbutton telephones. A customer can program his phone either by pushbutton-entory of the desired numbers or by sending a "marksheet" from his facsimile machine to the NTT center. When he reprograms his phone, any previously programmed number will automatically be removed.
A list of programmed phone numbers for abbreviated dialing will be made available, free of charge, for vertification of programmed numbers or for confirmation of phone numbers for multi-address communications.

(f) Multi-Address communications

This feature is only available to customers with pushbutton dialing service. It provides a simultaneous copy transmission service to a maximum of 100 addresses. A customer specifies the addresses to which he wishes to send copies, by pushbutton-entry of individual phone numbers, abbreviated dialing groups, or the special code for all phone numbers designated for abbreviated dialing. This feature allows him, for example, to simultaneously send a meeting notice to several parties by simply sending the notice once to the network, which saves him time and trouble.

(g) Confidential communications

Only a customer with pushbutton dialing service can send a confidential message (not exceeding 32 pages) by using this feature. Transmission of a confidential message is preceeded a brief notice to the addressee. He can then receive the message by dialing his identification (ID) code using either a pushbutton or rotary dial telephone. This feature strictly protects the privacy of customer communications.



An example of confidential message

(h) Facsimile mailbox

A customer who has registered for this feature with NTT can store his incoming facsimile copies in a "facsimile mailbox" which is installed at the NTT center. One hour after the arrival of texts or immediately upon deactivation, all stored messages will be delivered directly to the customer's facsimile machine, and normal transmission will resume. With this feature, a customer can receive incoming messages even when sending a large number of messages or being engaged in a long telephone conversation.

(i) Closed users group

This feature permits a group of specified users to communicate with each other, but precludes communications with any other users. This facility is available only to pushbutton dial customers who have registered for this feature with NTT.

(j) communications with Computers

This feature permits communications between a facsimile machine and a computer by converting facsimile signals into coded signals or vice

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versa. With this feature, a facsimile machine can be used to enter orders into a computer center or to retrieve information from the computer's database.

3.4 Facsimile terminals available

Facsimile terminals for which the FCNS is available are ISO A-5 size terminals (based on Group 2 machines) and ISO A-4 size terminals (based on Group [illegible] machines).
NTT provedes MINIFAX (A-5) and MINIFAX II (A-4).
In recent years, many other manufactures have provided facsimile terminals for which the FCNS is available.

3.5 Rates and charges

An advantage of the FCNS is its economy, especially for long-distance communications.
The communication rates over the FCNS are based on the distance and the number of pages transmitted; this is different from those for telephone calls.
For customers, such communication rates will be simple and easy to understand, and in proportion to the information volume.
The tariff is shown in Table 1.

(1) Non-Recurring Subscription Fee

¥800 per subscription

(2) Communication Rate per page

Distance	Rate for Standard Operation Mode		Rate for Fine Operation Mode	
	A-5 Size	A-4 Size	A-5 Size	A-4 Size
Upto100K	¥30	¥40	¥45	¥55
Over100K	¥40	¥50	¥60	¥70

Note; A surcharge of ¥15 is applide to every "confidential communication".

(3) Supplementary Service Charges

	Monthly Rental	Non-Recurring Installation Charge
a. Abbreviated Dialing (a) 40-number capacity	¥100	Basic Installation Charge ¥1700
(b) 100-number capacity	¥200	(Central Office Work Charge ¥700)
b. Facsimile Mailbox	¥350	
c. Closed-User Group	———	

Table 1 Tariff of FCNS

The distance is classified into only two steps, rather than the 13 steps for dialed telephone calls.
In comparison with charges between the telephone network and the FCNS, it costs ¥200 per page by the telephone network, but by the FCNS it costs only ¥40 per page. (These figures are for facsimile communications between Tokyo and Osaka (about 500 km) by MINIFAX).
Furthermore a customer pays only ¥800 for the initial subscription fee, and need not pay a monthly fee.

3.6 Service areas

In order to implement the FCNS, some special equipments must be provided for local switches. Therefore, it will take some time to expand the service area outside the larger cities.
Service has been provided to only 21 areas as of, July, 1984, but service will be extended to 293 areas, each with populations of over 100,000, by March, 1985.
Cites with populations of over 70,000 with be serviced by March 1986, at which time the number of areas will be about 630.
Therefore, the number of customers is forecast to increase greatly along with the expansion of the service area.

4. Upgrading of service

The FCNS was first put into service in September, 1981, as mentioned above, and was then upgraded in July, 1984.
The new FCNS provides services such as connections for G3 facsimile machines (A4 size), communications with computers, facsimile mailbox, confidential communications and closed user group service.
The old FCNS was a network mainly limited to MINIFAX, but due to the upgrading network the use G3 facsimile machines (A4 size) is forecast to greatly increase.
In addition to end-to-end communications between facsimile terminals, center-end communications between computers and facsimile terminals is expected to become more common.
The number of MINIFAX customers in the FCNS was about 12,000 as of September, 1984, at the same time the total number of the FCNS customers was about 13,000.

5. Applications

Along with the expansion of the FCNS, new applications have been developed in addition to ordinary facsimile communications.
The development of systematic facsimile communications has been especially remarkable; for example multi-address communications and communications with computers. (center-end communications)
The following are typical applications of the

FCNS. (including some which are under investigation)

5.1 The investors information service by securities company

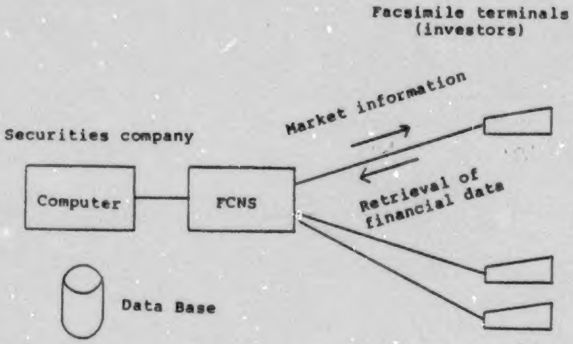
(a) Service concept

This service provides market information to investors with whom the company does business. This information includes stock prices, finances and exchange rates. The computer at the securities company is linked to the FCNS network (FDIC equipment) and transmits information to the investors' facsimile terminals by multi-address communications.
The investors' facsimile terminals can also access the computer through the FCNS network, and can retrieve various information from the data base, such as financial data and capital market information.

(b) Advantages

This information service is an effective tool to promote a securities company's business. Also, this service can constantly provide them with the newest market informations and the various other information from the data base at any time.

(c) System configuration



5.2 Information service for real-estate agents

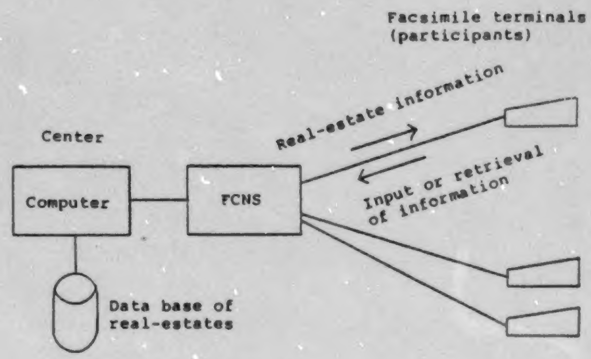
(a) Service concept

This information service is operated by the center, and is organized in conjunction with real-estate agents.
Both the computer at the center and the facsimile terminals at individual real-estate offices are linked to the FCNS network.
The computer center constantly transmits to participants up-to-date dealing information with maps and house layouts. (by multi-access communications)
Participants can input the necessary information to possible buyers, as well as retrieve such information for customers in the office.

(b) Advantages

Access to such a centralization of real-estate information should invigorate business activities.

(c) System configuration


Facsimile terminals (participants)
Real-estate information
Center
Computer
FCNS
Input or retrieval of information
Data base of real-estates

5.3 Education service for "gakushu-juku"

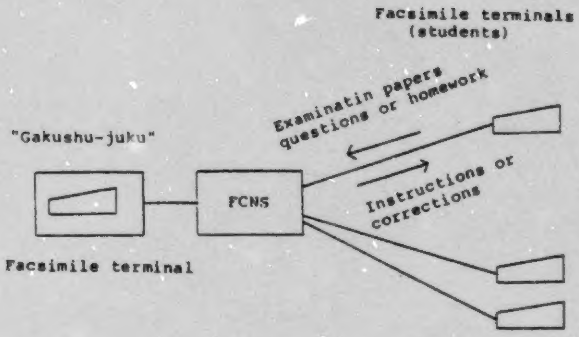
(a) Service concept

In Japan, there are a number of supplementary schools called "gakushu-juku", which students attend after daytime classes in regular schools. The FCNS is used by some "gakushu-jukus" in order to be able to give lessons to students at home.
The students can do their lessons at thome according to instructions sent from the "gakushu-juku" and then present papers to be checked by the instructor through the FCNS. In this service, the facsimile terminals at the "gakushu-juku" and the students home connected to the FCNS network for communications.
In the future, most of home will also be serviced by facsimile communications (called the era of home facsimile) and offering this educational service could be one step towards this era.

(b) Advantages

Students who live far from their "gakushu-juku" can be instructed with this service at home, and students and teachers can communicate about their studies at any time.

(c) System configuration


Facsimile terminals
(students)
"Gakushu-juku"
Examinatin papers questions or homework
Instructions or corrections
FCNS
Facsimile terminal

5.4 Order entry service for the chain stores

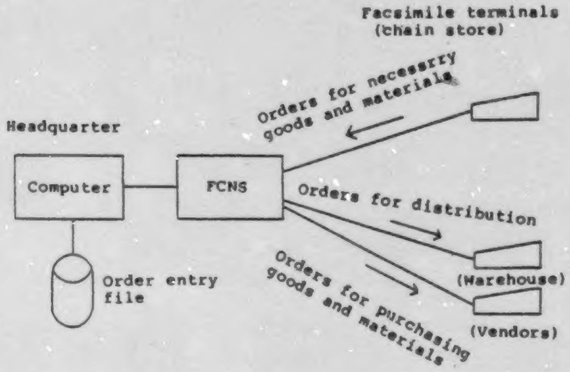
(a) Service concept

Recently the number of chain stores and restaurants in the Japanese market has been increasing.
Chain stores order a lot of goods and support material every day.
The headquarters, then, order to their warehouses or order purchases from vendors.
These are the ordinary procedures for order entry for chain operations.
This order entry service should supply an effective system for those procedures, using the combination of FCNS and computer.

(b) Advantages

In comparison with telephone communications which is relatively inaccurate and requires a great deal of manpower and data communications with data terminals which is expensive and difficult to perform, this system offers several advantages; availability of facsimile for better record keeping,cost-effectiveness, and ease of handling.

(c) System configuration


Facsimile terminals
(chain store)
Orders for necessrry goods and materials
Headquarter
Computer
FCNS
Orders for distribution
(Warehouse)
Order entry file
Orders for purchasing goods and materials
(Vendors)

6. Forecasting ---- Conclusion

In Japan, remarkable advancements have been made through development of ISDN network (called INS)
The model system has commenced operation in the suburbs of Tokyo in September, 1984.
Facsimile communications is one of the INS's core services, so the FCNS is regarded as one of its most important features.
Digital facsimile communications will commence nation-wide in 1986, when FCNS will support digital facsimile terminals (Group 4) as well as analog terminals.
At the same time, a variety of new services such as large scale multi-address communications will be added to the FCNS.
The number of facsimile terminals is expected to exceed 1 million in the near future. The FCNS will play an essential role in Japan's advanced information network of the future.

THE EVOLUTION OF VIDEOTEX

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1. Abstract

This paper examines the evolution of Videotex in Canada and North America, and defines three distinct stages of development. The first was the technical phase dominated by product definition and laboratory testing. The technology was designated as an important part of Canada's high technology strategy. The second phase was dominated by optimistic projections of mass market acceptance and the joint participation of the federal government and industry in numerous field trials. At the conclusion of this phase, the mass market was still elusive and major changes in the industry's strategy for introduction was recognized. The third phase saw major changes with the focus of activity on the US market, a trend toward home banking and interactive services, the development of micro-based NAPLPS software and a realization that government support would diminish in the near future. These developments led to major alterations in the industry structure and raised major questions about the future of Videotex in Canada.

2. INTRODUCTION

This paper reviews recent developments of Videotex in North America, with a prime focus on the Canadian situation. It emphasizes emerging industry developments and reviews overall business activity. In Canada, Videotex has evolved over the past five years through three very distinct waves of development. These are: Wave I - product development in labs; Wave II - mass market expansion and retraction; and Wave III - integration - re-orientation, innovation and redefinition.

2.1 Wave I

Wave I represents the development of Telidon at the CRC labs in Ottawa. Experiments during 1978- 1979 were taking place at CRC and Bell Canada to replicate the Videotex system being promoted by British Telecom, known as Prestel. The results of these experiments were announced in 1979 as Telidon, the Canadian version of Videtoex. Telidon was designed initially to use any communication medium: telephone lines, VBI, CATV, paired cables, satellites, optic fibres and TV broadcast. The basic elements of Telidon were also defined as an alpha-geometric coding scheme utilizing five basic forms (PDIs):

a. points
b. lines
c. rectangles
d. arcs and circles
e. polygons.

These are combined with the bit and control to make up seven basic commands to define a graphic image.

The second main feature of this period was the decision by the federal government of Canada to promote Telidon as an important feature of its long term program of support for high technology. A joint effort between government and industry was chosen as the way to encourage and ensure long term domestic and international success for Telidon. This resulted in the appropriation of $48 million from the federal government to support:

a. industry incentive programs
b. community information programs
c. public databases (Cantel)
d. international marketing
e. product development research
f. field trials and evaluation studies.

2.2 Wave II

The most significant part of the initial phase of the government's efforts to assist the industry was the implementation of field trials across the country to test the various configurations of Videotex and to evaluate the different approaches to service provision among a diversity of private and public organizations, agencies and companies.

This period was typified by the proliferation of field trials across Canada supporting a host of different service configurations, hardware and system operating features (Figure 1).

The trials represented joint ventures between the federal government and:

a. telephone companies
(Bell Canada, BC Tel)

FIGURE 1

TRIALS AND COMMERCIAL SERVICES IN CANADA, 1980-1983

Project/ Operator	Location	Operation	No. of Terminals	Transmission Medium
Project INET/ CCG-TCTS	Across Canada	July 1982	275	Datapac
Project CANTEL/ Task Force on Services to the Public	Across Canada	April 1982	100	Telephone Circuit
ELECTRONIC MESSAGE SERVICE/B.C. Tel	Vancouver, B.C.	Dec. 1981	200	Telephone Circuit
Project AGT-TELIDON/Alberta Government Tel.	Calgary, Alta.	Aug. 1981	30	Telephone Circuit
City of Calgary Telidon Field Trial	Calgary, Alta.	June 1982	Open Channel	Coaxial Cable
Project IRIS/ Canadian Broadcasting Corp.	Toronto, Ont. Montreal, Que. Calgary, Alta.	Sept. 1982	500	Broadcast
Project PATHFINDER/Sask. Telecomm.	Regina, Sask.	July 1982	125	Telephone Circuit
Project PALAIS DES CONGRES DE MONTREAL	Montreal, Que.	June 1983	TBD	Telephone & Coaxial Cable
Project MERCURY/ New Brunswick Telephone Co.	St. John, N.B.	Apr. 1981	45	Telephone Circuit (dedicated)
Maritime Telephone and Telegraph Trial	Nova Scotia	Mar. 1982	15	Telephone Circuit
Project CABOT/ Memorial University of Newfoundland	Newfoundland	July 1982	3	Telephone Circuit
Marketfax/ Cableshare	Canada	Nov. 1981	12	X.25 Digital Network
Premier Cablesystems	Vancouver, B.C.	Dec. 1981	Open Channel	Coaxial Cable
Project GRASS-ROOTS/Infomart and MTS	Southern Manitoba	May 1981	150	Telephone Circuit
Teleguide to Ontario/Infomart	Toronto, Ont.	June 1982	1,200	Telephone Circuit

FIGURE 1
(continued)

Project/ Operator	Location	Operation	No. of Terminals	Transmission Medium
Videopress/ Cableshare	London, Ont.	Nov 1981	6 interactive 6 non-interactive	Telephone Circuit
Project ELIE/ Man. Telephone System	Elie, Man.	Sept. 1981	150	Optical Fibre
Project IDA/ Manitoba Telephone System	South Headingley, Man.	June 1980 - Dec. 1981	33	Coaxial Cable
Ontario Telidon Network/TV Ontario	Across Ontario	Mar. 1979 Jan. 1980 Oct. 1982	55 100	Telephone Broadcast Telephone & Broadcast
Project VISTA/ Bell Canada	Toronto, Ont. Montreal & Quebec City, Que.	May 1981	491	Telephone Circuit
Project INFO-CABLE/Cable Telecommunication Research	Brockville, Ont.	June 1982 Fall 1983	Open Channel Number TBD	Coaxial
Telidon 2/Telecable-Videotron	Montreal, Que.	Fall 1982 Fall 1983	250 250	Teletext-Coaxial Videotex-Coaxial
Project AGORA/ Universite du Quebec a Montreal	Montreal, Que.	Apr. 1982	100	Coaxial Cable
Project NOVATEX/ Teleglobe	International	Feb. 1982	67	Telephone Network
Videotex America Field Trial/Times Mirror Videotex Services and Infomart	Rancho Palos Verdes & Mission Viejo CA	Mar. 1982	200 phone 150 cable	Telephone & Coaxial Cable
Time Inc. Teletext Trial	Orlando FA San Diego CA	Fall 1982	150	Satellite & Coaxial Cable
Bakersfield Telidon Trial	San Joaquin Valley CA	Fall 1982	500	Telephone Circuit
WETA Teletext Service	Washington, D.C.	May 1982	64	Broadcast
Myer Emporium Telidon Trial	Australia (countrywide)	Mar. 1983	TBA	Telephone
Venezuela Telidon System/Infomart	Caracas, Venezuela	Early 1981	25	Telephone Circuit

b. cable TV operators
   (Videotron)

c. broadcasters
   (TV Ontario, WETA)

d. system suppliers
   (Infomart).

The main purpose of these trials was: to promote the technology by introducing the services to the public, to demonstrate Canadian expertise, stimulate hardware production, to assist industry in developing a cost effective product and to allow initial assessment of the public's reaction to services.

This wave was typified as well by very optimistic forecasts of the likely success of the technology, with estimates of a penetration of 500,000 homes by 1984 not uncommon. In fact, the forecasts for 1984 made in Canada between 1980-1982 ranged between a low of 40,000 terminals to a high of 600,000. There was as well great promise held for the technology to be the basis of a mass market in-home information utility combining information retrieval with alarm monitoring, meter reading and computer-based education.

By the end of 1982 the realities of the marketplace began to take shape and it was clear that optimism was not being matched by the response of test case users to the various systems. In most trials, user response was only moderate with the main criticism centering on:

a. Lack of stimulating and interesting content.

b. Poorly defined search procedures and overly complex tree structure.

c. Slow response time for on-screen presentations.

d. Limited application diversity and utility.

e. The limited gateway possibilities for linkage to a variety of databases.

f. The lack of attention to integration with existing technologies such as PCs and management work stations.

g. The variability in norms and standards of page production, maintenance and design.

h. The inability to update information quickly and to avoid redundancy in large databases.

i. The over reliance on hardware, technical capabilities and networking rather than content, applications and human factors issues.

j. Limited market needs analysis and application development.

This evolutionary stage resulted in a significant amount of retrenchment among suppliers when a less than enthusiastic response was detected from the different trial settings. At the same time, changes were occurring in standards and in competition from alternative systems and service suppliers. The US market also began to emerge with companies such as Times Mirror, Viewtron, CBS and AT&T announcing their own Videotex ventures. Finally, the federal government of Canada, while acknowledging important lessons had been learned from the trial experiences, nevertheless announced that the Telidon program would not be funded beyond 1984.

In Canada, this announcement caused major concern among many industry players, since it relied heavily on government support. At the end of the main field trial phase there were still no commercially profitable services, although several trial activities were continued as commercial ventures. the most notable of these were Grassroots, Teleguide, Faxtel and Genysis.

The user population in late 1982 was less than 5,000 terminals distributed over the various field trial sites. The largest concentrations were in Infomart's Grassroots service and the Bell Canada Vista trial. Business accounted for approximately 25% of all installations.

A review of the various trials conducted in Canada reveals the majority offered information retrieval services to residents and the business market. Teleshopping was limited and none offered telebanking. The bulk of the trial activity had been undertaken by the telephone companies, with 11 of the trials accounting for the placement of approximately 1,500 terminals. Cable companies were also involved, operating five trials with a placement of close to 500 terminals, largely in the home market. In addition, commercial services were started as joint ventures under the federal government program. An example of one of these is the Teleguide system in the province of Ontario with approximately 1,200 terminals. Education experiments were undertaken using the Telidon technology through the TV Ontario and the CBC broadcast trials.

At the conclusion of Wave II in late 1982, industry participants began to respond to the disappointing results and experiences by adjusting their approaches to the emerging realities of the marketplace. The interest for interactive services, the linking to microcomputers (already established in many homes and businesses, particularly in North America) and the emphasis on specific target groups and unique applications was seen as increasing the likelihood of the industry's longer term development. Videotex per se gradually began to be seen as but one additional feature of a variety of established high technology, hardware and software products.

The experiences of the early years emphasized the difficulties inherent in predicting the course of new technologies, and highlighted the effect regulation, technological change, standards, consumer preference, government policy, competition and market forces play in directing the acceptance and market penetration of new technologies.

2.3 Wave III

The past two years have seen quite dramatic changes in the nature and orientation of the Videotex industry in Canada and the US. Canada had been recognized as a leader in Videotex, first with the development of Telidon and then with the successful adoption of the NAPLPS standard. A shift of significant dimensions, however, has taken place among industry participants.

Assessments of the market opportunities for Videotex are beginning to focus on areas quite different from those originally envisioned. No longer, for example, is a mass market for in-home standalone Videotex seen as a likely possibility (at least in a non-subsidized market). In addition to the high price of such terminals, a number of complementary technologies with higher market penetration lend themselves to Videotex applications at a much cheaper price than is currently possible with the purchase of a standalone terminal. NAPLPS Videotex is now more likely to be seen as an add-on feature of a management workstation, embedded as graphic software in an office automation product or to emerge on personal computers as software for business and office applications.

Also emerging is a recognition that very specialized applications, such as those for in-home transaction services, banking and shopping, are likely to provide an important impetus that could lead to further penetration within selected segments of the consumer market, and to significant further business development.

Major service providers, Bell Canada and BC Tel, decided not to continue their participation. One of the largest on-line retrieval services (Novatex) was recently terminated after expenditures of $4 million, and the federal government has indicated it will not continue subsidizing the industry beyond its most recent contribution of $5 million for content development.

While the original players in this industry were telephone companies, newspaper publishers and the federal government, today banks, financial service companies, software and high technology firms represent key players.

The emergent developments in this so-called Wave III of Videotex can be explained to a large extent by examining issues related to regulation, standards, software innovations, competition and market trends. Also in Canada, it has become quite evident that cable industry activity will be a major force dictating the direction of Videotex services to the home and business market in the near future.

3. REGULATION

One explanation of the reticence of Canadian telephone companies to plunge further into Videotex, in addition to the uncertain results achieved in the field trials, is regulation. The regulation of content-based services provided by federally regulated companies, such as Bell Canada and BC Tel, is still not settled. Recent decisions by the regulator have indicated that the traditional separation of carriage and content will be rigidly adhered to, at least in the near future. Until a different regulatory stance is made, the telephone companies in Canada are not likely to make large commitments to the implementation of Videotex services. Their interest, quite naturally, will lie in network utilization and the potential revenue that can accrue from the carriage of content rather than the development and operation of full scale Videotex.

In Canada and the US there is a strong movement among all local operating companies toward usage sensitive pricing for local services, a direct outgrowth of deregulation. This means that no longer will charges for calls be based on a flat fee, as is currently the practice. If usage sensitive pricing becomes universal, there are likely to be significant revenues and cost impacts for the end users of any network-based service (voice or data). Given that customers are known to be quite price sensitive toward tariffed Videotex services, additional user charges will have dramatic effects on their likelihood for market success.

4. STANDARDS

The settling of the North American Presentation Level Protocol Syntax, or NAPLPS, is one of the most significant industry developments in the past two years. In 1983, AT&T, Bell System, DOC and the Canadian Telidon Agency augmented picture description instructions were published by the Canadian government. This led to the formation of the current standard, NAPLPS. In the US, work is now underway to develop NAPLPS chips by Western Electric, Synotech, Motorola and Intel, and it is expected that by 1985 manufacturers will be able to buy NAPLPS chip sets at prices close to $100 US. Canadian manufacturers are now using this standard in their products, with Norpak and Electrohome manufacturing and marketing NAPLPS and NABTS chip sets and decoder boards for Videotex and Teletext.

A key factor in the near future will be the rate of take-up by the personal computer hardware manufacturers of these chip sets. A significant amount of development has taken place, and a number of large computer companies have shown interest, including Apple, IBM and DEC. This will give further endorsement to the NAPLPS standard encouraging further manufacturing and ultimately price reductions for decoders and suitably equipped PCs. Also, the European CEPT standard and world standard Teletext incorporate the NAPLPS protocol. In Southeast Asia, Japanese manufacturers are examining this protocol with interest, and it has also been adopted in Singapore and South Korea.

NAPLPS represented an improvement on Telidon, providing an enhanced capability for almost photographic level images (one of its greatest advantages). Its independence of hardware technology is also considerable, such that terminals may have high, medium or low resolution and have different ranges of colour capabilities. NAPLPS allows for these variations and has what is referred to as forward and backward capability. The incorporation of the Unix screen concept ensures that pictures will be displayed independent of the hardware configuration, and objects within pictures will remain in the same relative position with respect to each other, even though the resolution of the physical display may be changed.

Additional conforming features have also been identified by Lum: (1)

> Videotex and Teletext services using NAPLPS can have blind interchange, i.e. the database need not negotiate on the capabilities of the terminal before sending out the data. Database information pages created for Videotex and Teletext can be easily interchanged, ensuring a widescale portability of database pages.
>
> A unified specification for Vdieotex and Teletext allows the design of one VLSI chip set and encourages manufacturers to build larger volumes of the product rather than small volumes for each of several specifications.

The specific features of the NAPLPS protocol are outlined in Figure 2.

5. NAPLPS MICROCOMPUTER VIDEOTEX SOFTWARE

One of the most encouraging developments for Videotex over the past year has been the growth of companies producing microcomputer-based NAPLPS software. Most microcomputers equipped with the appropriate software and add-on modules can serve as decoders, page creation terminals or integrated database systems for NAPLPS Videotex. A wide variety of microcomputer-based software and hardware products using the NAPLPS standard are now on the market, and the software industry is showing a significant interest and confidence in their growth and potential.

Currently a number of Canadian companies are producing programs for encoding or decoding NAPLPS, with prices ranging from $100 to $500 for decoder software, and from $500 to $2,500 for encoding software. The price of NAPLPS decoder software at the present time is currently in the $700 to $1,000 range. NAPLPS decoding software packages are widely available for a number of personal computers, including the Commodore 64, Apple II, IBM PC and other compatible machines.

Page creation and database systems are also available. Software for NAPLPS page creation using micro computers are produced by companies such as Cableshare, Tayson, Lumicon, Formick, Async, Microtaur and TV Ontario. These systems require the use of a NAPLPS decoder for display of the pages on a monitor. Also available are microcomputer-based mini database systems which open up the possibility of developing medium or large scale Videotex systems without using a mainframe computer. Such systems are particularly suitable for public access or local area network oriented applications (Figures 3 and 4).

6. NAPLPS AND ASCII

The settling of the NAPLPS standard has generally been perceived quite positively by the Videotex industry. There are still, however, a number of uncertainties about its relative impact on industry developments. These stem primarily from cost implications to the end user and cost effectiveness for system operators and terminal manufacturers, as well as the relative merit of NAPLPS vs ASCII-based systems, which are to a large extent applications specific. At the present time ASCII services predominate, although NAPLPS has the capability to grow quite dramatically in the next few years.

While the settling of standards and development of NAPLPS software are encouraging caution should still be exercised before assuming rapid take-off. In Canada, at the present time there are approximately 3,000 users of NAPLPS-based services which derive mainly from Grassroots and Teleguide. There are, by comparison, at the present time in North America 200,000 users of some form of ASCII-based Videotex services, and there is an estimated population of more than six million ASCII terminals in North America, 25% of which are already equipped with telecommunications capabilities. Since it is not likely that NAPLPS equipped micros will become as widely available in the marketplace until at least in the 1990s, the main competitor in the short term for NAPLPS-based services, are ASCII-based services such as The Source and Compuserve. Another important consideration is the penetration of colour monitors into the micro marketplace. It will be important for NAPLPS software to become compatible with a variety of microcomputers since the market is still very fragmented despite the early dominance in the business market of the IBM PC.

7. PERSONAL COMPUTERS AND SOFTWARE DEVELOPMENTS

The rapid growth of microcomputer-based NAPLPS is based, of course, on the burgeoning PC market. In 1982 there was an installed base of 4.5 million microcomputers in home and business markets in the United States, and in 1983 the installed base had grown to approximately 9 million units, with a 1984 projection of something on the order of 15 million

FIGURE 2

NAPLPS - FEATURES AND IMPLEMENTATION REQUIREMENTS

	Functions	SRM Requirements
1.	Character Sets	- 94 Primary (ASCII) - 94 Supplementary
2.	Geometric Drawing Primitives (PDIs)	- Point - Line - Arc - Rectangle - Polygon (256 vertices) - Incremental point - Incremental line - Incremental polygon - 256 vertices limit for Polygon and Spline
3.	PDI Attributes:	
	- Domain	- Single-value operand - Multi-value operand - 2 & 3 dimensional modes - Logical pel
	- Text	- Rotation in 4 directions - Move in 4 directions - 4 inter-character spacings (1, 5/4, 3/2 and proportional) - 4 inter-row spacings (1, 5/4, 3/2 and 2) - 4 attribute combinations - 4 cursor styles - display formats (40x24, 40x20, 40x10, 32x16 and 20x10)
	- Texture	- 4 line textures - 4 define & 4 programmable masks - highlight in all colours
	- Colour	- 3 colour modes (0, 1 and 2) - 16 colours out of 512 palette
	- Blink	- 16 simultaneous blink processes
	- Wait	- 0 - 1/10 sec minimum duration
	- Reset	- Selective
4.	Mosaic Set	- 65 codes
5.	Macro Set	- 96 macros
6.	DRCS	- 96 characters
7.	Control Sets:	
	- C0	- Execute and present all
	- C1	- Create macro, DRCS and programmable masks - 40 unprotected fields

Source: Chang, K., "Videotex through Microcomputers with a Review of Current Developments in Canada," Ottawa, April 1984.

FIGURE 3
MICROCOMPUTER-BASED TELIDON/NAPLPS DECODERS

Company	Base Micro-Computer	Memory Required	Operating System	Language	Display Resolution	Simultaneous Colors	Extra Hardware Required	Remarks
[illegible]	Commodore 64	64K	C64 Kernal	Assembly	320 x 200	2/ch.cell 16 palette	No	Cartridge based
[illegible]	Commodore 64	64K	C64 Kernal 3.2 or 3.3	C and Basic	320 x 200	8 colours or 8 greys	No	
	Apple II, II+, IIe	48K	Apple DOS	C and Basic	180 x 140	6 colours or 8 greys	No	
NORPAK/APPLE	Apple II, II+, IIe	48K	DOS 3.3	Pascal	128 x 96	15	Telidon interface card	
MICROTAURE	IBM PC,XT	128K	PC DOS	Machine	256 x 200	16/512	Real Colour colour card	Features inc.: downloading, slide show printing
MICROSTAR	IBM PC,XT	192K	PC DOS	Basic & Assembly	320 x 200	16	Plantronics colour card	Also available for Hyperion, Compaq, Columbia, etc.
[illegible]	IBM PC,XT,PCjr	128K	PC DOS 1.1 or 2.1	Forth	320 x 200	16	Techmar or Plantronics colour card	
MICROPIXEL	IBM PC,XT	NIL	PC DOS 2.0	Machine	256 x 200 x4 planes	16 out of 16 million	[illegible] 100-based Board	Full IBM 16K Telesoftware, 8K Macro Composite video output
MANITOBA TELEPHONE SYSTEM	Commodore 64	64K	C64 Kernal	Machine	160 x 200	13 + 3	No	3 out of 13 colours and 3 gray shades per ch. cell
FORNIC	Apple IIe	64K	DOS 3.3	Machine	256 x 190	16	Texas card	Also requires a 64K, 80 col. card

FIGURE 4
MICROCOMPUTER-BASED PAGE CREATION SYSTEMS

Company	Base Micro-Computer	Memory Required	Operating System	Language	Display Resolution	Extra Hardware Required	Remarks
CABLESHARE Picture Painter	IBM PC, XT DEC Rainbow	128K 256K	PC-DOS CP/M 86/80	C C and Basic	256 x 200 256 x 200	NAPLPS Decoder, Graphics Tablet	16 text fonts; XFER software ava. for direct transfer to database
TAYSON Vast	IBM PC, XT	128K	CP/M MS-DOS	C and Basic	256 x 200	NAPLPS Decoder, Dual Drive or Hard Disk	
LINICOM Prodraw	Sony SMC-70	64K	CP/M	C	256 x 200	NAPLPS Decoder, Graphics Tablet	File transfer pkg and cycle software available as extra
FORNIC	Apple II	48K	DOS 3.3	Machine	256 x 200	NAPLPS Decoder Fornic (ROM) Card	Communications pkg. available
ASTRC Videographic System	Apple II IBM PC,XT	64K 128K	P. System UCSD P. System UCSD	Pascal Pascal	256 x 200 256 x 200	NAPLPS Decoder NAPLPS Decoder, Quickpel card	NAPLPS to NTSC interface available Scrip for file management
TV ONTARIO Createx C	IBM PC,XT	128K	MS-DOS	C	256 x 200	NAPLPS Decoder, Quickpel card	Features inc. Page compression, Auto-shading, cont. scaling.
NORPAK/APPLE Telidon Graphic System	Apple II	48K	DOS 3.3	Pascal	128 x 96	Telidon Interface card	Not yet NAPLPS compatible
MICROTAURE M.P.C.	IBM PC, XT	256K	PC-DOS	Assembly & C	256 x 200	1 extra screen	Built-in Software Decoder, SCRIBE ava. for NRCS creation.

BEST COPY AVAILABLE

units. It is predicted that the Canadian computer industry will grow by 20%, with personal computers expected to comprise almost $8 billion of the total predicted domestic computer market. In 1983 the installed base of microcomputers in Canada was estimated at 58,000 with a growth rate of 300% predicted for business micros selling under $10,000. Advanced Resources Development reports that the sales of perscoms will exceed $2 billion by 1986 with more than 7 million shipped between 1987-1986. (3)

One of the most significant developments within the software industry has been the growth of AI, or artificial intelligence. Recent studies examining the opportunities in artificial intelligence have noted the possibilities of combining Videotex into a hardware and software system for machine translation. Videotex in these situations would operate as a display means and enable the human translator to carry out the final editing of initial machine translation in restricted domains. AI software enables a computer to imitate aspects of human thought and is coming commercially into the marketplace through such products as Intellect of the Artificial Intelligence Corp. This allows naive users to request data from computers with typed English sentences rather than convoluted commands. Intellect is a non-procedural query language, meaning that a user does not have to follow the strict logical sequence of a computer language.

In most AI Intellect installations the typical number of users is 50-100, most of whom have never used a computer. A major area which AI-based software may radically change is how to search for information in computerized data and information databanks. This is particularly significant for current Videotex systems where the complexity of the search procedures introduces a number of limiting features into the operations of the system.

More recent developments with AI and Videotex involve the emergence of natural query languages in conjunction with Videotex software and laser discs as a storage and retrieval system. The use of natural query language facilitates the search procedure through the host database and replaces the need for complex tree structures and keyword search processes.

8. APPLICATIONS & SERVICES

8.1 Banking & Shopping

In Canada the commercial Grassroots service has emerged as the most successful, along with the government initiated Teleguide service, with close to 2,000 and 500 respective terminal locations. These, however, have not yet been shown to be profitable services despite significant assistance in the form of hardware procurement, government grants and content development.

The focus of industry attention has now shifted to the US where NAPLPS and ASCII-based interactive services are currently being promoted. There, over 80 banking and related interactive services and a growing number of business related on-line transaction services which have proliferated in the past two years (Figure 5).

The Canadian movement toward home banking has been considerably more constrained than in the US due to a more conservative business attitude, less competition in the provision of banking services and stricter regulatory controls. However, in Canada, as in the US, there have been corresponding developments in automated banking, ATMs and multibranch banking systems. In 1983 there were 32,000 ATMs installed in the US while there were 7,600 in Canada controlled by the five major banks. (4) These developments, along with the desire by banks to realize savings in labour and transaction costs, are encouraging the growth of home banking, shared networks and franchising of in-home services.

Growth in home banking and financial services will likely closely follow the diffusion rate of home computers in North America. Thus, the diffusion of perscoms suitably equipped to conduct transactions in either ASCII or NAPLPS protocol is of critical importance to this industry. Figure 5 reveals the current market situation for the different in-home banking services in the North American market.

8.2 Bank of Montreal/Infomart

In 1983 the subscribers to Grassroots -- a Videotex-based agricultural information service of Infomart -- were offered a home banking service with the Bank of Montreal. Using a gateway, Infomart subscribers can access the Bank of Montreal's home banking services. These include transfers from one account to another, review of account statements and the ability to balance accounts. To be added in the near future are services such as bill paying, Master Card activities, and some limited loans -- all by using the Videotex terminal in the home. The Grassroots service is located in Winnipeg, Manitoba and serves agricultural communities throughout Manitoba, Saskatchewan, Alberta and Ontario. Subscribers can also access the Greenshields stock exchange service, the Winnipeg Commodity Exchange, the Chicago Mercantile Exchange, the Mid-America Exchange and the Chicago Board of Trade.

9. INTERACTIVE SHOPPING IN CANADA

Shopping and product information is now widely used as a promotional tool for building traffic in stores, and many selected retailers are using Videotex-based systems to advertise products and services as well as to provide prices and locations where products could be purchased. Systems are in place which use touch screens, cable television, personal computers, videodiscs and voice synthesis for in-store service, inventory systems and as a means to market computer products. Various forms of teleshopping sales are estimated to exceed $5 billion by 1985 and to reach $20 billion by 1990. (5) Approximately 85% of the

FIGURE 5

HOME BANKING SERVICES AND TRIALS, 1983

System Operator	Project	# of On-Line Users	Area
ADP Telephone Computing Service	HBI	2,000	Seattle, WA
CBS Venture One	Venture	300	New Jersey
Chemical Bank	Pronto	500	California, New York, Florida
Compuserve, Inc.	-	30,000	All of US
Continental Telecom	Contelvision	100 households	Manassas, Virginia
Financial Interstate Services Corp	Bank-At-Home	500	Knoxville, Memphis, Boston
First Interstate	Day and Night Video Banking	200	Los Angeles
Indax-Cox Cable	Indax	600	San Diego
Infomart	Grassroots	300	Western Canada
JC Penney	Firsthand	200	N. Dakota
Keycom Electronic Publishing	Keycom Videotex Service	3,000	Chicago
Macrotel, Inc.	-	218	US
Shamut	-	100	Boston
The Shuttle Corp.	Shuttle Information Service	-	Redmond, WA
Source Telecomputing Corp.	The Source	36,000	US and Overseas
Times/Mirror Videotex Service	Gateway	1,000	Misson Viego, Palos Verdes, CA
The Treasurer, Inc.	Venture One	100	Ridgewood, NJ
Tymshare	-	-	International
Videofinancial Services	Viewtron	3,500	South Florida
Bank of America	-	7,000	N. California S. California
IBM/CBS/Sears	Trinitex	-	-
Delphi Videotex System	Delphi Network	-	Banking interchange Network
Madison National Bank	Hometeller	500	Madison Wisc.

North American Videotex/Teletext trials include some form of home banking or home shopping in their service offerings. Many, although not all, use NAPLPS or some variant of Telidon compatible presentation level protocols, but the majority are still based on ASCII.

A review of the various field trials conducted in Canada between 1981 and 1983 revealed that the majority offered information retrieval services to residents and the business market. In no case was a fully interactive shopping or banking service offered. Retailers such as the Bay and Eatons and banks such as the Royal Bank, Bank of Montreal, Bank of British Columbia and various credit unions and trust companies provided pages of product and service information. As well, in local markets, speciality suppliers such as stereo and consumer electronics retailers were quite active in putting up sales information in the Grassroots service. The Bay provides product and shopping information and banking transaction services.

Teleguide is the public access information service launched in September 1982 by Infomart with the co-operation of the governments of Ontario and Canada. There are over 500 Teleguide terminals located in shopping centres, hotel lobbies, tourist and transportation centres. The service offers current guides to attractions, shopping, restaurants, entertainment, accommodation, sports and recreation and other information on events in Toronto and throughout Ontario. Teleguide has recently announced the incorporation of services such as gold and precious metals futures, sports scores, rock albums and a guide to AM and FM radio stations.

A recent addition to Teleguide allows guests in selected hotels around Toronto to use a desktop Videotex terminal in their rooms. The hotels participating are Howard Johnson's, Royal York, Skyliner, Sheraton and Weston. Each hotel has wired rooms and suites to receive Teleguide services. The trial provides up-to-date information such as broadcast news, business wire services, real time Toronto Stock Exchange quotations, a variety of computer games and a teleguide to Toronto. In addition, the hotels will offer information on facilities and services including an electronic function board outlining hotel business meetings and conferences, dining specials and entertainment information. A number of possible special applications are being considered such as on-line convention registration, electronic messaging and on-line checkout. (6)

Cableshare's Videopress system uses interactive Videotex in an NAPLPS-based system for advertising and shopping information. This is being operated in four Canadian malls in Toronto, London and Montreal. The system is also in use in Iowa, Texas, Minnesota and Michigan. Shoppers can access mall directories, sales and in-store specials, compare prices, availability and obtain new products.

10. CABLE INDUSTRY DEVELOPMENTS

In Canada, in the past few years there has been an increasing amount of activity and interest by cable TV companies towards providing non-programming and interactive services. This stems from the fact that revenues from services such as Pay TV and all movie channels, have not been as successful as initially anticipated. As a result, the industry is currently looking at ways to increase its service offering and to gain a share of the market for interactive and non-programming services in home banking, shopping, downloading of computer software, interactive business graphics, software market information, financial services and commodities exchange. Although business networks have not yet undergone significant development, they comprise the most significant opportunities for new applications. There are also significant opportunities for cable in providing broadband transactional capabilities to the residential market. Cable can provide features such as sound, downloaded software, computer games, teleshopping and banking, with content sent to a specific subscriber via an addressable terminal.

CATV firms have been experimenting with banking and home shopping, and have demonstrated the use of video pictures in association with graphic information. Such technology uses video disc players with cable TV along with forced tuning. A forced tune ability allows a subscriber to change back and forth from video to Videotex to access product information. Video discs, used with two-way cable systems, provide a near instantaneous switching of video and graphic images. Several firms are now producing such systems in the US, Canada and Europe. Sears Department Store in the US placed its 1983 summer catalogue on video disc. Using a random access search capability, a combination of video disc, perscom and efficient networking has rendered it as a useful mechanism for video catalogues in high traffic areas such as airports, malls, hotel lobbies and point of sale displays. In 1983 there were 1,300 such video merchandising systems, which are expected to grow to about 14,000 by 1985. (7)

A 1983 study examining the cable industry in Canada indicated that approximately 20% of its revenues will arise from the sale of non-video services by 1990. (8) It is anticipated that by 1990 tiered services of Videotex/Teletext plus all transaction services will comprise revenues on the order of $500 million in Canada. As the growth of new systems develop worldwide, most will be oriented toward two-way cable. In Canada, approximately 60% of all homes have cable. Most is one-way, requiring significant technical modifications in preparation for these new services. Already, attention is focused on upgrading major markets to two-way services and to the production of cheap decoders.

11. SUMMARY

The Videotex industry in Canada has evolved quite substantially over the past five years, undergoing very distinct waves of change. Today the industry is very much in transition as government support is reduced, telephone companies become more cautious and new strategies for product development and marketing are required.

Combining Videotex (NAPLPS) with a variety of display and storage technologies for special applications in business, public service, arts and culture has been shown to be successful and to offer market opportunities. Specialized applications utilizing artificial intelligence and distributed systems for storage are increasingly seen as overcoming the problem of large data bases, computer and network capacity, complex search procedures and tree structures. These, combined with enhanced display systems such as ETV and HDTV, will allow the relative benefits of NAPLPS to emerge.

On-line interactive banking, financial services and shopping applications are believed to be economically beneficial to business (reducing costs and offering more efficient services) and have received significant positive response from test users where user charges are either fully internalized (by the provider) or highly subsidized.

In business, NAPLPS graphics for office automation, on-line information retrieval, interactive services for finance and banking have been assessed quite positively but still face significant competition from existing technologies offering comparable functionality, usually at lower prices and with less need for acquiring peripheral support services.

In Canada and the US, very few telephone companies are operating as service providers. Trends in competition, regulatory structures and the increasing movement to local measured services mean price structures for all interactive services could be significantly altered. Cable TV suppliers may be the most logical service providers as non-programming services become more critical to revenue generation. This aspect will also be relevant to Europe as cable penetration increases and telephone monopolies adjust to increasing competition for networks and service provision.

The growing penetration of microcomputers with graphics and colour monitors provides significant opportunities for NAPLPS software and VLSI-chip sets for conversion. The majority of these are in business, underscoring the importance being placed on business graphics and information access. More important are the specialized market sectors likely to use these services -- medicine, animation, real estate, advertising, banking, investment and travel.

In Canada, much of the industry activity has been implemented because of government support. This applies to the original field trial activity and to a lesser extent the current commercial services. The government program now being terminated requires the industry to become more innovative in its product development, marketing and operation. The main focus of the industry is increasingly being directed to the expanding US market for Videotex software, VLSI-chips and system implementation.

FOOTNOTES

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FIGURE 6

BANKING-AT-HOME SOFTWARE AVAILABLE IN THE US*

DATA PROVIDED BY
CEP INTERNATIONAL
NEW YORK

SOFTWARE FINANCIAL SERVICES	COMPANY OR BANK							
	CHASE** PAYMATIC	CHEMICAL PRONTO	FINANCIAL INTERSTATE	SOUTHEAST BANK (VIEWTRON)	ADP	*** HOMESERV	APPLE	E-Z SOFTWARE
ACCOUNT BALANCE INQUIRY	YES	YES	YES	YES	YES	YES	NO	YES
BILL PAYING	YES	YES	YES	YES	YES	YES	NO	NO
CREDIT CARD ACCOUNT REVIEW	NO 1984	YES	YES	YES	YES	NO LATE 1983	NO	YES
PAYMENT MECHANISM FOR HOME SHOPPING A) DIRECT SETTLEMENT B) CREDIT CARD	NO	YES	NO	FUTURE YES	NO 1983	YES	NO	NO LATE 1983
INVESTMENT INFORMATION FOR BANKS INVESTMENT VEHICLE -- CD'S, ETC.	NO	YES	YES	YES	YES	YES	NO	YES
PURCHASE OF BANK INVESTMENT VEHICLES	NO	YES	YES	NO MID 1985	YES	PLANNED	NO	PLANNED
LOAN INFORMATION	NO	YES	YES	YES	YES	YES	NO	PLANNED
ACTIVATE LOANS	NO	YES	YES	NO LATE 1984	YES	PLANNED	NO	NO
PURCHASE TRAVELERS CHECKS	NO	NO	NO	NO	YES	NO INFO. ONLY	NO	NO
JOINT ACCOUNT INFORMATION	NO	YES	YES	NO	YES	YES	NO	YES
PERSONAL BUDGETING CALCULATION	NO	YES	PLANNED	PLANNED	YES	NO LATE 1983	YES	YES
PREPARATION OF TAX RETURNS	NO	CATALOG [illegible] DEDUCTIONS	NO	NO	NO	NO MUCH LATER	NO	NO
INFORMATION ON STOCKS AND BONDS	NO	NO 1984	NO	NO	YES	YES	YES	NO
ACTIVE LOANS	NO	YES	YES	NO (1984)	YES	PLANNED	NO	NO
INTERACCOUNT FUNDS TRANSFER	YES	YES	YES	YES	YES	YES	NO	NO
A) ADVANCE FROM CREDIT CARD ****	NO	YES	NO	YES	YES	YES	NO	YES
B) ADVANCE FROM BANK LINE OF CREDIT ****	NO	YES	NO	YES	YES	YES	NO	NO

* SOFTWARE AVAILABLE FOR LICENSE AS OF JANUARY 1983, EITHER WITH A TURNKEY SYSTEM OR BY ITSELF.

** AS OF APRIL 1983, CHASE HAS DECIDED TO DISCONTINUE PAYMATIC ACTIVITIES.

*** HOMESERV IS NO LONGER OPERATIONAL.

****SUCH ARRANGEMENTS HAVE BEEN MADE TO LINK THESE SERVICES TO THE PROPER ACCOUNTS.

FIGURE 7

SYSTEMS OPERATOR/SERVICE PROVIDER - FUNCTIONS AVAILABLE

SYSTEMS OPERATOR/SERVICE PROVIDER	BALANCE INQUIRY	BILL PAYING	CONSUMER SERVICES	ELECTRONIC STATEMENT	ELECTRONIC MAIL	FINANCIAL SERVICES	FUNDS TRANSFER	GAMES	INFORMATION RETRIEVAL	TELESHOPPING
ADP/TCS	●	●	●		●	●	●	●	●	●
CBS VENTURE ONE	●	●	●	●	●	●	●	●	●	●
CHEMICAL BANK	●	●	●	●	●	☐	●			☐
COMPUSERVE	●	●	●	●	●	●	●	●	●	●
CONTINENTAL TELECOM	☐	☐	●	☐			☐		●	☐
FINANCIAL INTERSTATE SERVICES	●	●	●	●	●	●	●		●	●
INDAX/COX CABLE	●	●	●	●		●	●	●	●	●
J.C. PENNY	●	●	●	●	●	●	●		●	●
KEYCOM	☐	☐	●	☐	●	●	☐		●	☐
SHUTTLE CORPORATION	●	●	●	●	●	●	●		●	●
SOURCE TELECOMPUTING			●		●	●			●	
TIMES MIRROR VIDEOTEX SERVICES	●	●	●	●		●	●		●	●
THE TREASURER, INC.	●	●	●	●	●	●	●		●	●
TYMSHARE	●	●	●	●	●	●	●			
VIDEOFINANCIAL SERVICES	●	●	●	●	●	●	●		●	●
VIEWDATA CORPORATION	●	●	●	●	●	●	●		●	●

☐ - SERVICE PLANNED

CONSUMER SERVICES	FINANCIAL SERVICES	INFORMATION RETRIEVAL
EDUCATION	BUDGETING/ACCOUNTING	NEWS
ENTERTAINMENT	FINANCIAL PLANNING	SPORTS
FIRST AID	STOCK TRADING/INFORMATION	WEATHER
LIBRARY	TAX PREPARATION	
TRAVEL		

PROTOCOL

SYSTEMS OPERATOR/SERVICE PROVIDER	ANTIOPE	ASCII	NAPLP	PRESTEL	TELIDON	PROPRIETARY
ADP/TCS		●	●			
CBS VENTURE ONE			●			
CHEMICAL BANK		●	☐			
COMPUSERVE		●				
CONTINENTAL TELECOM	●		☐			
FINANCIAL INTERSTATE SERVICES		●				
INDAX/COX CABLE						●
J.C. PENNY	●					
KEYCOM			●			
SHUTTLE CORPORATION		●	●			
SOURCE TELECOMPUTING		●				
TIMES MIRROR VIDEOTEX SERVICES					●	
THE TREASURER, INC.			●			
TYMSHARE		●				
VIDEOFINANCIAL SERVICES			●			
VIEWDATA CORPORATION			●			

☐ - CONVERTING TO

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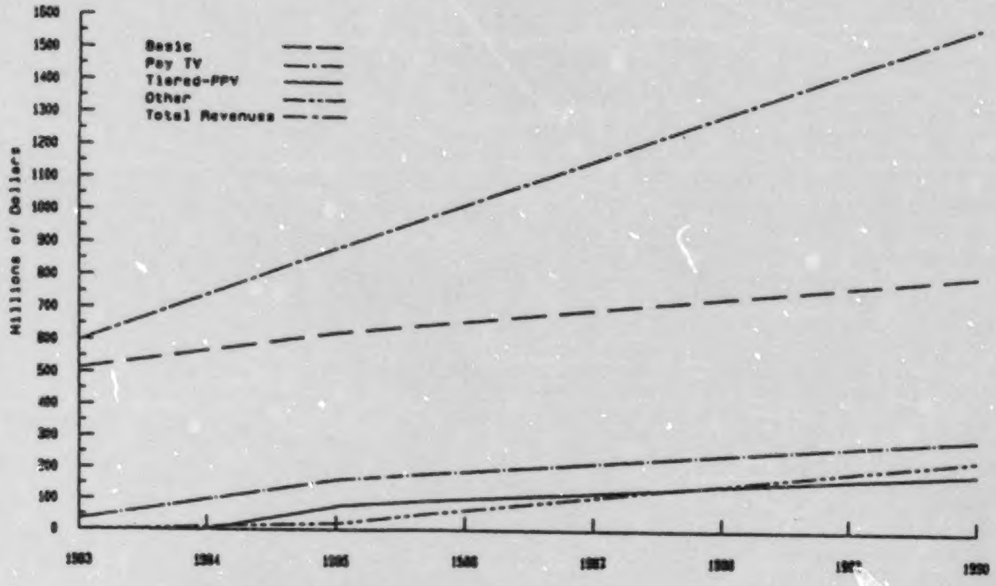
FIGURE 8

PROJECTED CABLE OPERATOR REVENUES FROM NEW SERVICES



Note: Other services include personal computers, games, Teletext and Videotex, security and telemetry, and interactive and transactional services.

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GLOBAL THIN-ROUTE SERVICES USING INTELSAT: DIGITAL AND ANALOG SOLUTIONS

Joseph N. Pelton and T. Michael Kelley
INTELSAT

1. ABSTRACT

INTELSAT's use of digital modulation/multiple access techniques for thin-route international communications began in the early 1970's, with SCPC/PCM/PSK and SCPC/PCM/PSK with Demand Assignment (SPADE). Both international and domestic thin-route requirements have increased dramatically since then, as smaller earth stations and equally innovative modulation/multiple access techniques, both digital and analog, have evolved. Now, INTELSAT can supply thin-route data distribution services using "microterminals" with 0.75-meter antennas, and single voice channel service from earth stations with 3-meter antennas.

This paper traces the development of the wide variety of thin-route services offered by INTELSAT. It explains the background for the choice of modulation/multiple access techniques, adapted for existing services, and outlines the major facets of INTELSAT's future in an increasingly digital communications environment.

2. INTRODUCTION

In studies by the ITU and other organizations dedicated to improving telecommunications in developing countries, the economic and social benefits of improved communications have been demonstrated consistently. Improvements in the delivery of health care, educational material, and agricultural information are but a few of the possible benefits to be enjoyed. To respond to this opportunity as rapidly and economically as possible, some developing countries have turned to one of the newest and most powerful advances in long-distance communications: the communications satellite.

Satellites have at least four characteristics that make them an attractive alternative when compared with other means of long-distance communications: the cost of using a satellite is independent of distance, geography and climate; satellites can broadcast television and radio to all of a nation's territory; satellites are very reliable; and, use of a satellie permits a direct link among any number of locations served by earth stations. This last advantage of flexible network connectivity makes satellites particularly attractive, because of the ease with which the network can expand, contract, and avoid losses in service due to failures in any single network node. The utility of this advantage is seen most graphically for rural and remote service, when small, low-cost earth stations can operate in the most isolated locations, separated from other settlements by oceans, deserts, or jungles.

Both developed and developing countries alike have been taking advantage of these four principles since 1973, when INTELSAT first introduced SCPC (Single Channel Per Carrier) service using demand-assignment known as SPADE in its international network. A short time later in 1975, domestic leases began to operate using SCPC, starting with Algeria and Brazil. In most cases that followed, such domestic systems were used to connect remote locations with national and regional capitals. In the case of international SPADE service, a digital technique was chosen (SCPC/PCM/PSK), but in the vast majority of domestic leases, an analog technique was chosen (SCPC/FM with companding). Thus, the era of "thin-route satellite service using INTELSAT," dates from the mid-1970's. The debate over the relative merits of digital and analog modulation techniques for "thin-route" service has continued ever since.

"Thin-route" service has gained great attention during the last decade, as has the push toward the use of "small", "low cost" earth stations. Some confusion has resulted, in that these terms have evolved to have different meanings over time. In the mid - 1970's, "small" INTELSAT earth stations were Standard B's with 11m antennas. INTELSAT Standard Bs were first utilized to carry "thin-route" international SCPC/PCM/PSK service primarily between developing countries (who needed only a few full-time channels) and developed countries on the Primary (i.e. high connectivity) satellite. Now, INTELSAT's "small" earth stations range in size from 75 cms to 4.5 meters and range in cost from $2500 to $250,000. These earth stations have a wide range of functions, such as transmitting and receiving one or two voice channels to serve remote areas (VISTA), receiving 9.6 kbps signals using "spread-spectrum" techniques in urban or rural areas (INTELNET), and transmitting and receiving 1.544 Mbps data from the rooftops of skyscrapers (INTELSAT Business Service). Small, low cost earth stations are now really small and as satellite power is increased they will become smaller still.

For the telecommunications infrastructure of the Pacific Basin, all of these INTELSAT applications of small antennas and thin-route service can play a significant part. The following survey of INTELSAT's long-established services and some of its new innovations which are aimed primarily as serving the needs of developing countries will illustrate the diversity of roles that analog and digital techniques are serving now and will serve in the future.

3. EVOLUTION OF THIN-ROUTE SERVICE USING INTELSAT

A. SPADE

In the early 1970's, INTELSAT's solution to thin-route international service in the highly fragmented multiple pathway South Atlantic region of the INTELSAT network was the well-known SPADE System. (SPADE was an acronym signifying Single channel per carrier, PCM/PSK, Multiple Access, Demand Assignment, Equipment). Using demand assignment, pairs of channels between two locations were assigned only when a telephone call was made, (i.e. on demand) rather than assigning channel pairs on a permanent basis. This technique permitted more efficient use of transponder capacity, and permitted charging "by-the-minute" (much like the charging for telephone service) rather than "by-the-channel" on a full-time monthly basis, as was done for channels in the remainder of the INTELSAT network.

The PCM/PSK digital modulation method was adopted to match relatively well-known terrestrial technology. Analog voice signals from the terrestrial network were processed at the earth station one at a time and converted to a digital format, as there were relatively few digital terrestrial systems at the time and certainly no "customer- premise" earth stations. In fact, system efficiency depended on the use of large Standard A earth stations, the "pooling" of available circuits, and the advantages of time-zone shifts in peak usage and "voice activation" of individual channels. In 1974, 13 countries participated in the SPADE network. There was a total of 26 pathways, and about three-million minutes of service was used. The system now includes 35 countries, serves over 300 pathways, and carries some 45-million minutes of traffic per year. However, due to the high cost of SPADE equipment and its optimized design to serve networks with hundreds of pathways, SPADE was not suitable for implementation in the Pacific or Indian Ocean Regions.

B. SCPC

The desirability of standardizing a technique for providing thin-route international service in the Pacific and Indian Ocean Regions was clear because the demand for such service was great. In 1975, INTELSAT took three simple steps to establish such standards. First, the well proven analog-to-digital SCPC technique developed for SPADE was retained, but the complex and hard to maintain demand assignment equipment was not required. Secondly, transponder loadings were devised that were based on use of smaller (11-meter) antennas and the Standard B earth station was introduced. Thirdly, because the use of Standard B earth stations did not permit as high a capacity as was possible with Standard A's, a "rate adjustment factor" of 50 percent was added to the standard utilization charge for a 4 kHz voice channel received by a Standard B station. The consequence was that the Standard B earth station user paid more for each channel, but paid much less for the construction and maintenance of the earth station. The economics of this arrangement were much more favorable for both developed and developing countries alike, and there are now 84 Standard B earth stations using digital PCM/PSK, including 19 in the Pacific Ocean Region.

Of the some 3,500 SCPC channels now operating in the INTELSAT system, some 750 channels are in the Pacific Ocean Region, with about half allocated to Standard B earth stations. The majority of these SCPC channels carry voice and/or low-speed data (e.g., telex, teletype, facsimile) but about 5 percent carry high speed data (e.g. 56 kbps for computer-to-computer data transfer).

C. Domestic Leases

During this evolution of digital SCPC in the INTELSAT international network, domestic thin-route applications in Alaska (using RCA SATCOM), Indonesia (using PALAPA), and other areas with difficult geography and climate, were expanding. The multiple access technique chosen most often was still SCPC, because FDM/FM was unsuitable for small numbers of channels serving large numbers of locations. Time Division Multiple Access (TDMA) and Code Division Multiple Access (Spread-Spectrum) were many years away from commercial exploitation. At this time, INTELSAT was having great success in the leasing of spare capacity for the establishment of domestic networks. While typical applications involve the creation of long-distance networks among regional capitals and major cities, there was also a parallel need to provide thin-route voice service to rural and remote areas. The vast majority of countries did not choose digital SCPC but rather, at their own option, adopted SCPC/FM with "companding" (i.e., with compression trunk and expansion of the voice signal) as their modulation technique because of its simpler and cheaper design than SCPC/PCM/PSK. In fact, in INTELSAT domestic leases, there are now roughly 5000 individual SCPC/CFM channels scheduled for operation, and it has certainly been the predominate thin-route technique of the last several years.

4. VISTA: ANALOG AND DIGITAL SOLUTIONS FOR REMOTE AREA COMMUNICATIONS

INTELSAT's VISTA service was approved in December of 1983, and was described in some detail at PTC '84. VISTA is both a domestic and international service, specifically designed to promote the use of small, simple, low-capacity earth stations for provision of voice and low-speed data services to remote areas. VISTA networks are normally dedicated to domestic voice communications to remote areas, or are specifically tailored for closed communities of interest at the international level. Connection into the regular INTELSAT overseas network must be through a Standard A, B, C, E or F earth station. The standard modulation/multiple access technique adopted for VISTA is SCPC/FM with companding and voice-activation, with 30 KHz spacing between channels. Four VISTA networks are known to be in the final planning stages: a) a U.S. Government link between Oman and the U.S.; b) an oil company link between Madagascar and the U.S.; c) a public link between mainland Australia and the Cocos Islands in the Indian Ocean, and d) a private link between mainland Chile and territories in the Antarctic. The detailed planning by SPEC for the South Pacific Ocean region is also carefully examining VISTA as a prime option.

VISTA is provided on a preemptible or non-preemptible basis, at a monthly charge for a full-time one-way channel of $265, for preemptible service; while the fully protected charge is $525 per month. The minimum period for lease is three months and the maximum term is one year with automatic renewal. The service is currently available on INTELSAT V global beam transponders on non-Primary and Major Path satellites in the Atlantic, Indian and Pacific Ocean Regions.

The advantages and equipment design of SCPC/FM with companding have been well-documented. Digital techniques, however, have several well-known advantages over analog FM that can be applied to reducing the costs of small thin-route earth stations. Digital SCPC using 32 kbps with Delta-Modulation, has a flatter power spectral density than SCPC/FM and therefore can cause less interference into networks operating on adjacent satellites. As a consequence, earth station antennas can be somewhat smaller using this technique, all else being equal. Secondly, the use of digital techniques permits the combination of several individual channels to modulate one carrier. Since the earth station transmits only one carrier, rather than several individual channels, the advantages of reduced antenna size, smaller transmit power requirements, or both, can be exploited. Thirdly, digital transmissions can be coded in a manner that permits successful reception at lower carrier-to-noise (C/N), again permitting reductions in antenna size and transmit power.

There are currently several manufacturers who offer equipment packages employing each of the above-described methods. INTELSAT is actively investigating if these techniques are compatible with the frequency reuse environment found on INTELSAT satellites, the receive sensitivity of INTELSAT satellites, and internationally recognized technical agreements with other satellite operators. Furthermore, in looking to the future, INTELSAT is well-aware that new advances in both solid-state technology and in the so-called low-rate encoding techniques make the digital path look increasingly attractive.

INTELSAT is indeed studying the appropriate mechanisms for introducing digital techniques in VISTA. This expansion of VISTA could perhaps be accomplished by extending the newly defined Standard G earth station to cover Digital VISTA application. In this respect, a Canadian-sponsored satellite, projected to provide health and education services to the South Pacific under INTELSAT's Project SHARE,* envisions an experimental test of digital VISTA terminals next year. In proceeding with digital VISTA, however, it must be clearly distinguished from the INTELSAT Business Service (IBS) and other INTELSAT international service offerings, in order to ensure both service protection and tariff equity to all INTELSAT users.

The adoption of SCPC/CFM at this stage in the standardization of VISTA was more a recognition of its current predominant role in the marketplace than a final endorsement of SCPC/CFM as the only technique possible. Standardization of modulation/multiple access technique was crucial in the original planning for INTELSAT's international network, because the entities corresponding with each other needed to know the single technique that would ensure their participation in new links as their demands grew. However, it is anticipated that requirement for VISTA service will arise in two circumstances where rigid standardization is not as critical: a) small domestic networks where one administration has control over the methods used by all correspondents; or b) small communities of interests that may combine domestic and international networks, where entry into the network is open only to a known community of users. In these cases, INTELSAT believes that users could be free to select whichever modulation/multiple access technique is most suitable for their requirements.

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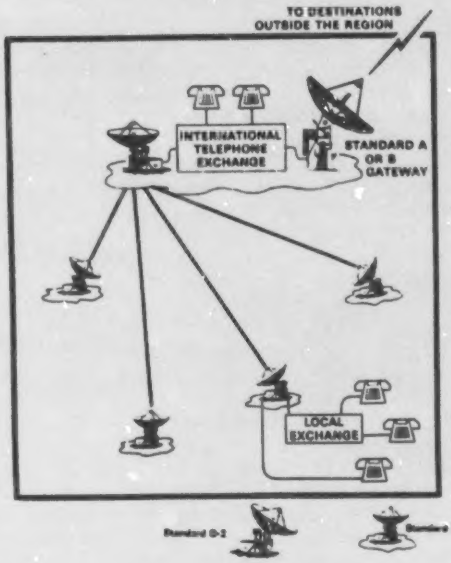
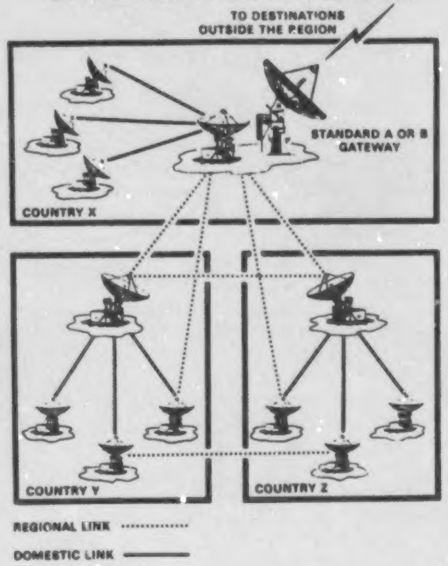
*Project SHARE (Satellites for Health And Rural Education) is a 16-month period of free tests and demonstrations, lasting from January 1985 to April 1986, when INTELSAT will donate the use of its satellites for the delivery of health care and educational information.

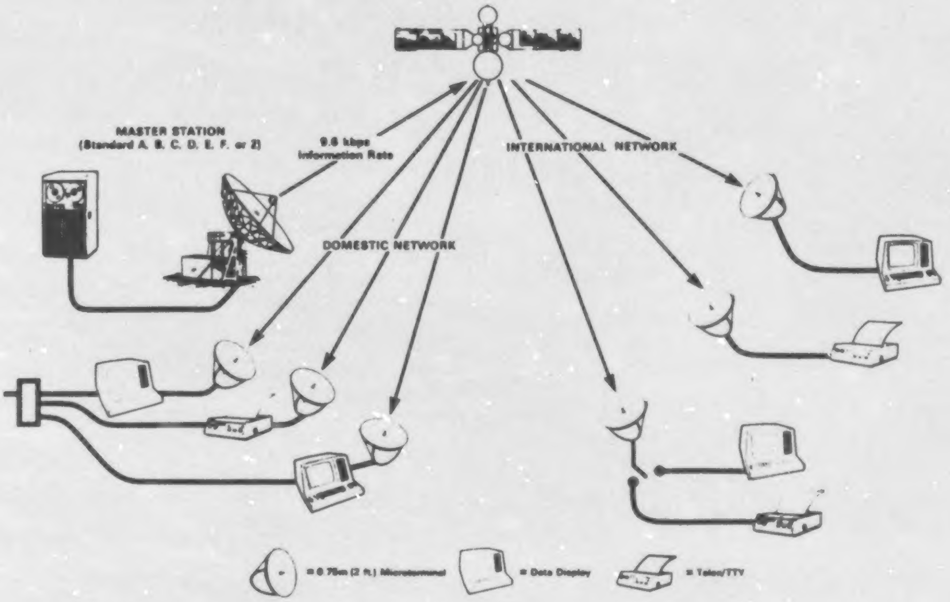
TYPICAL VISTA APPLICATION


TO DESTINATIONS OUTSIDE THE REGION
INTERNATIONAL TELEPHONE EXCHANGE
STANDARD A OR B GATEWAY
LOCAL EXCHANGE
Standard D-2
Standard D-1

DOMESTIC/REGIONAL VISTA NETWORK WITH STANDARD A OR B GATEWAY


TO DESTINATIONS OUTSIDE THE REGION
STANDARD A OR B GATEWAY
COUNTRY X
COUNTRY Y
COUNTRY Z
REGIONAL LINK
DOMESTIC LINK

INTELNET


MASTER STATION (Standard A, B, C, D, E, F, or Z)
9.6 kbps Information Rate
INTERNATIONAL NETWORK
DOMESTIC NETWORK
= 0.75m (2 ft.) Microterminal
= Data Display
= Telex/TTY

5. INTELNET: THE POWER OF DIGITAL CODING

One fully digital technique that takes maximum advantage of advances in coding technology is termed Code Division Multiple Access (CDMA) or simply "spread spectrum" coding. Using the wide bandwidths available on satellites, the signal transmitted is more than 99 percent "coding" and less than one percent "desired information". However, the value of this technique is that it permits very extensive reception by hundreds or even thousands of very simple "microterminals" with antenna diameters as small as 0.75 meters (2 feet). For applications where direct voice communication by satellite is not critical, such as for the distribution of printed news items, commodity prices, weather forecasting, etc., this technique is an ideal solution to the problem of reaching widespread remote areas.

Many industries and government organizations, as well as private and aid-oriented agencies, depend critically on their ability to distribute information to and gather information from remote places. A globally interconnected satellite network which provides data and voice coordination channels between small, inexpensive terminals and a large central hub earth station(s) would prove to be an indispensable tool for achieving these objectives in an efficient manner. INTELSAT is in a unique position to offer these services on a global basis, and in October 1984 INTELSAT approved a service designed for this purpose, called "INTELNET."

INTELNET microterminals are particularly well-suited for applications in rural and remote areas because they are small, light-weight, easily transportable and can operate with a small amount of prime electric power. Large numbers of these can be deployed at widely distributed locations, either domestically or international, for the reception of one-way broadcasts of any printed material that is compatible with the presently approved rate of 9.6 kbps. One or more central "hub" earth stations, which may serve many other international and domestic communications needs (e.g., television broadcast, business users, etc.) are the sources of the data distributed in the INTELNET network, with microterminals located where the reception of data is required.

INTELNET will be provided in either the C-band or Ku-band on a full-time lease or "occasional-use" basis. Depending on individual coverage, connectivity, and capacity requirements, leases will be allocated in increments of 9 MHz. The earth segment will have to comply with the INTELSAT Standard G performance characteristic (BG-60-60), and the use of space segment will be in accordance with INTELSAT leased transponder definitions.

The INTELNET services are provided on a preemptible and non-preemptible basis. Tariffs for non-preemptible INTELNET service are consistent with rates for IBS full and fractional transponders. The preemptible INTELNET service is provided on available transponder capacity on existing satellites other than Primary or Major Path satellites and the tariffs are consistent with those for preemptible transponders leases used for video service.

6. INTELSAT AND THE DIGITAL FUTURE

INTELSAT has plans to continue its leadership role in the supply of digital satellite transmissions for all users, big and small. During the next few years TDMA/DSI will be introduced in the Atlantic and Indian Ocean regions in order to improve the efficiency of our trunk services and to complement the move toward fully digital microwave and fiber-optic terrestrial networks. Satellite-Switched TDMA, with its enhanced connectivity, is under study for introduction in later generations of the INTELSAT VI satellites.

INTELSAT is working with its Signatories and users in the Pacific Ocean region to schedule the introduction of these techniques as they are needed to meet their requirements. For those countries who anticipate participation in existing and new submarine cable projects, INTELSAT will provide restoration services at attractive rates and at a minimum of technical and operational complication. INTELSAT is also watching developments in the 20/30 GHz band, particularly the US NASA Advanced Communication Technology Satellite (ACTS) and the Japanese NASDA and NIT programs. These experimental satellites will feature on-board processing and regeneration of digital signals. This may ultimately allow the development of very simple TDM terminals that may cost under $50,000 and could be used for either customer-premise or rural and remote communications services.

In the coming months, INTELSAT will also be exploring the introduction of two-way microterminal communications into the INTELSAT network. The terminals be specifically designed for single-channel, INTELNET digitally-encoded transmission toward large hub earth stations and can be unattended and controlled by the central hub stations. It is possible that terminals costing in the range of $10,000 to $15,000 could be developed to supply voice service to remote areas. We hope that a test and demonstration of such a terminal will be conducted during 1985, perhaps as part of Project SHARE. These terminals also would be particularly useful for data gathering applications, where a central computer facility is repeatedly receiving transmission from remote sites, which may share satellite capacity and transmit only when requested by signals from the central controller.

7 . CONCLUSION

The INTELSAT system has a challenging role in global satellite communications. It must meet the requirements of 109 member countries and some 60 more users, whose needs can range from one part-time voice channel for a village on a remote island in a developing country to hundreds of international circuits between major world powers. The earth stations now accepted within the network range from "microterminals" costing a few thousand dollars to multi-million dollar Standard A's. INTELSAT responds to this challenge with the technology appropriate to meet these requirements, including both analog and digital modulation and multiple access techniques. In the past, INTELSAT has kept pace with the evolution of digital satellite communications, and will be responsive to the coming digital revolution.

DIGITAL TECHNIQUES FOR SCPC NETWORKS

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Abstract

Every facet of modern telecommunications is being changed by the accelerating rate of developments in digital techniques and VLSI circuit capabilities. This is certainly true in the field of satellite systems, and digital SCPC networks provide inexpensive, efficient, versatile, and adaptable communications for thin route applications.

This paper explores the general advantages of digital SCPC networks, followed by a closer look at tradeoffs involved in the capacity of transponders. The many options available for digital processing of the signals are discussed, with special emphasis on speech coding. Finally, the status of digital SCPC systems in Canada is described.

INTRODUCTION

Satellite communications offer good solutions to many dispersed thin route requirements.

Advances in digital techniques and solid state technology make it very attractive to implement these satellite networks with digital transmission. The digital techniques allow for very interesting tradeoffs between complexity, cost and performance with respect to both baseband processing, modulation and utilization of the satellite resource.

ADVANTAGES OF DIGITAL TECHNIQUES

World wide trends in communications clearly point towards a system where various services share a common all-digital network. The cost effectiveness of digital switching is well proven and the penetration of digital microwave radio and digital fibre optic systems is growing. Satellite transmission systems are also, to an increasing extent, taking advantage of digital techniques.

Heavy route satellite systems have largely been implemented with analog techniques, although digital TDMA systems have been in service for some time. Intelsat will shortly introduce an advanced 120 Mb/s TDMA system, a major step in the development of digital satellite communications.

Both analog and digital thin route SCPC systems have been in operation for many years. Continuing advances in digital techniques now make the latter systems more attractive than ever (1).

Telecommunications have been and still are largely dominated by voice traffic. Data services and other non-voice requirements are continuously growing in demand and importance and will represent a significant portion of the future expansion of communications services. Simultaneous provision of transmission capabilities to satisfy all service demands, present and future, strongly favour a digital implementation.

With rapid advances in digital processing techniques and their implementation on VLSI circuits, there are also benefits in quality, size, reliability and power consumption. This technological trend shows no sign of stagnation, and systems chosen for implementation now should be able to benefit from the progress which will take place during their expected lifetime. A properly designed and implemented digital system offers this 'insurance' against premature technical obsolescence.

Diversification in service quality will most likely follow the present expansion of service offerings. Toll grade voice quality may not be necessary or economically justified in applications such as remote tele-education and emergency communications. Low cost, simplicity and ruggedness may be the driving forces in

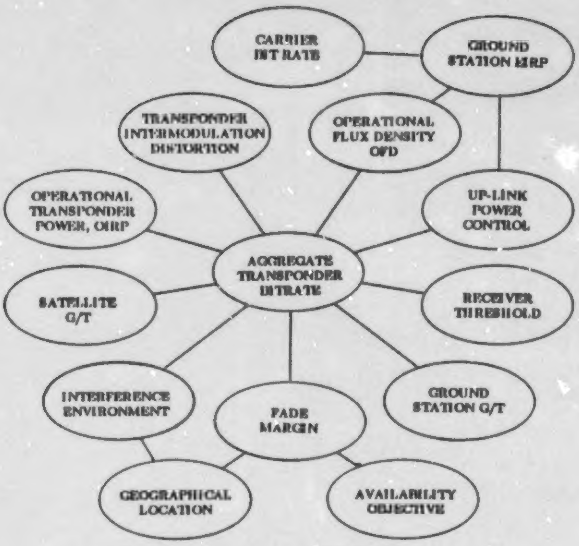

FIGURE 1. FACTORS DETERMINING ATB

these applications, and again, digital systems allow the freedom to select the appropriate technique from a large number of available options.

Digital systems are often well standardized at a digital cross connect point but have less developed standards at other points. It has, for example, been rather common to interconnect analog microwave radios through mid-air connections. That is not possible with most digital microwave systems. Similar trends are evident for fibre optic and digital satellite systems. On the other hand, digital carriers show good energy dispersal characteristics and low interference susceptibility. This allows great freedom and efficiency in transponder allocation, making the utilization of shared transponders simpler to implement.

Communications security demands are constantly growing and can be adequately served only through a digital carrier system.

Provision of high quality service at a low cost is obviously the main concern. The cost of ground station hardware and maintenance is one major cost component, and transponder charges represent the other major factor. The actual cost per year of a transponder is often outside the control of the communication service provider. As this cost is 'fixed', the more bits which can be sent through a transponder simultaneously, the lower the cost per bit. Efficient use of the transmitted bits is the obvious next step towards inexpensive communications.

TRANSPONDER CAPACITY

In most multicarrier (SCPC and FDMA) satellite systems, the achievable transponder capacity is limited by the available power rather than the available bandwidth. The maximum total bitrate of all digital carriers in a transponder can be named the Aggregate Transponder Bitrate (ATB), and Figure 1 shows some of the factors determining the ATB (2). It is interesting to note that the ATB is largely determined by the satellite parameters, receiver performance and performance expectations. Assuming a large number of digital carriers giving a well distributed transponder intermodulation noise floor, the actual bitrate of individual carriers does not affect the ATB. On the other hand, receiver performance in terms of G/T and threshold level have a direct impact on the ATB. A tradeoff between ground and space segment cost must be made for each individual situation. One typically finds that heavy route networks, with few nodes, have large groundstations to maximize ATB. In SCPC networks, with a large number of ground stations, the combined cost of many large stations is prohibitive and a cost optimum is found using smaller antennas at a reduction in ATB. SCPC networks can easily regain some of the ATB using burst carrier activation.

The direct benefit of a lower voice coding rate is obvious considering a fixed ATB for systems with other parameters unchanged. A voice coding scheme with high tolerance to channel bit error rate will have a similar impact on ATB and hence reduce the recurring cost for the lease of the space segment.

<table>
<tr><td colspan="2">MODULATION
SPECTRUM SPREADING
ENCRYPTION
ERROR CORRECTIVE CODING
ACTIVITY DETECTION</td></tr>
<tr><td>ERROR CONCEALMENT
SPEECH CODING
ECHO CONTROL</td><td>DATA REDUCTION
DELAY COMPENSATION
PROTOCOL CONVERSION</td></tr>
<tr><td>VOICE</td><td>DATA</td></tr>
</table>

TABLE 1. DIGITAL PROCESSING COMPONENTS

DIGITAL PROCESSING

Effective 'treatment' of the signal being put on a carrier is of great importance to the overall cost-effectiveness of a satellite SCPC system. The areas where digital processing can be applied are summarized in Table 1 and are discussed below.

Phase or frequency shift keying is typically used as a modulation method in digital SCPC systems. Four phase (QPSK) modulation is the most common while two phase (BPSK) modulation is relevant where excess bandwidth is available. The power efficiency is similar between these modulation methods and does not affect the ATB. The demodulation method, however, determines the received threshold level and has a direct impact on the transponder capacity. Coherent demodulation gives the most efficient detection and is commonly used to maximize system efficiency. There is ongoing work in the combination of modulation and coding to achieve further advancements in the utilization of the satellite resource.

Simple scrambling of baseband data is used to spread the spectrum evenly and thus limit RF interference. This technique is easy to implement and does not require any increase in bit rate.

Encryption can be used to provide secure voice and data communications where such protection is required. The emergence of the Digital Encryption Standard and compatible VLSI processors have made this option more cost effective.

Forward Error Correction (FEC) is an effective way to trade power efficiency for increased bandwidth. A number of techniques are available. Burst systems often use Block Codes while continuous transmission favours Convolutional Encoding with either Threshold, Viterbi or Sequential decoding. An absolute power coding gain of up to 5 dB at a 10E-7 BER is achievable at moderate complexity. It is important that the FEC algorithm chosen for application in an SCPC system be matched with the modulation method used.

An important advantage of digital SCPC systems is their ability to interface directly to high speed (up to 56 kb/s) data communications equipment and terminals. A requirement for baseband data interfaces is that they be adaptable to the various synchronization schemes and network protocols in common use. It is important that the internal protocol used to control data transmission via the satellite channel is designed to cope with the large transmission delay involved.

Many users require both digital voice and data communications, in which case both services can time share a single channel. Of course, some users may still want to send data via voiceband modems, and the implications of this requirement will be covered when speech coding is discussed.

It is usually necessary to multiplex signalling and frame synchronization bits with coded voice or data bits to implement an effective, flexible system. Tone signalling can be used for voice service but minimum performance limits are then imposed on the speech codec and flexibility is sacrificed. Telephony signalling, including hook-switch status, dial pulses, ring control, call seizure, and channel test codes, can easily be digitized and combined with the voice bits. This is also true for RS-232 data interface signals. A digital signalling codec can easily provide robust protection against bit errors and bursts of random data received when frame synchronization is lost. Allocation of about one percent of the bit stream to a framing pattern will provide for robust framing performance. The framing pattern must be carefully chosen to minimize the probability of it being mimicked by voice, data, or signalling bits. The signalling codec and frame synchronizer are easily combined onto a single chip processor.

The ability to use any of a wide variety of speech coding techniques is a special advantage for digital SCPC systems. The available speech codecs allow a choice of quality, bit rate, signal range, BER sensitivity, and complexity. These fall into two broad categories: toll quality and communications quality codecs.

For many SCPC networks toll quality is required, including more than good speech reproduction alone. The channel must be fairly transparent to 1 KHz test tones, DTMF and MF signalling tones, moderate speed data modem signals (up to 9.6 kb/s), and occasionally telegraphy or facsimile signals. Speech coding techniques which can achieve this level of performance are generally restricted to waveform coding at 16 to 64 kb/s. Waveform techniques which can provide toll quality speech are Mu-law or A-law companded Pulse Code Modulation at 64 kb/s, Adaptive Differential PCM at 32 kb/s, and Adaptive Delta Modulation at 32-56 kb/s. Sub Band Coding, Adaptive Predictive Coding and Adaptive Transform Coding are candidates for even lower rates down to 16 kb/s.

The Mu-law and A-law Pulse Code Modulation (PCM) coding algorithms at 64 kb/s are the digital telephone network CCITT standards for international communications. PCM codecs achieve a Signal to Noise Ratio (SNR) of greater than 33 dB, a dynamic level range of over 40 dB, and the ability to handle data modem signals up to 9600 b/s. Facsimile and voice band telegraphy can also be handled. The codecs are transparent to all standard types of tone signalling and test tones. Single chip PCM codecs are available from almost every major semiconductor manufacturer at low cost. The major disadvantages of PCM coding for digital satellite systems is the high bit rate required and the relative sensitivity of this method to high BER.

The CCITT has recently approved the standardization of a coding algorithm at 32 kb/s which gives almost equivalent speech performance to PCM with low error sensitivity. This algorithm is known as Adaptive Differential PCM (ADPCM) and has been under development at research labs worldwide for many years. ADPCM can also handle up to 4800 b/s modems and is transparent to all tones and facsimile, but can not be used with telegraphy. In ADPCM the difference between the input PCM sample level and a predicted level is coded rather than the input PCM sample itself. If the predictor is very accurate the difference will have much less dynamic range than the input, so fewer bits need to be transmitted. Implementations of this algorithm are not yet on the market but it is reasonable to expect that the cost will be moderate and that no more than two or three chips will be required to implement a full speech codec.

Adaptive Delta Modulation (ADM) codecs use similar algorithms to ADPCM, but much simpler. In this case the differences are encoded as either a positive or negative result so only one bit is needed per sample. The coarseness of the quantizer is balanced by increasing the sampling rate, which in this case is equal to the channel bit rate. At 32 kb/s, state of the art ADM codecs can achieve an SNR of 25 - 30 dB, dynamic range of 30 - 40 dB and almost transparent transmission of tone signals. Most modem signal formats can be transmitted up to 2400 b/s at least, but facsimile and telegraphy transmission are not feasible. ADM codecs are well known for their robust operation at high BER, and have been a popular choice for use in digital satellite systems. Further advantages of ADM are its low cost and simple implementation.

Other more complex techniques, such as Sub-Band Coding (SBC) Adaptive Predictive Coding (APC), and Adaptive Transform Coding (ATC), promise the possibility of toll quality at rates down to 16 kb/s but they are still in the research stage. However, with the steady increase in capability of Digital Signal Processing (DSP) chips, it may not be very long before four telephony grade channels can be sent at the bit rate required for one channel only a few years ago.

Studies in the literature (3 and 4) comparing the performance of various toll quality digital coding techniques, including those described above, have concluded that digital codecs can perform equivalent to, or better than, companded FM channels.

In the case of some SCPC applications, including many of those proposed for the future, only communications quality speech coding is required. This describes methods which often reproduce artificial sounding speech, can not handle non-speech signals, and often have problems coding speech with high ambient noise levels. The algorithms generally employ parametric speech coding at 1.2 to 9.6 kb/s, and include Linear Predictive Coding (LPC), Vector Quantization, Spectrum Coding, Formant Coding, and Tree Coding.

The above algorithms are still active areas of research, and reports in the literature give variable, but generally similar, performance results for all. LPC coding has advanced far enough to be considered as an option for SCPC networks. LPC involves the calculation and transmission of various speech parameters, including an estimated filter model of the speaker's vocal tract, a decision as to whether an utterance was voiced or unvoiced (e.g. vowel or fricative), the pitch of the sound, and the energy contained in the analyzed speech segment. Intelligibility of common LPC algorithms is well over 90% at 4.8 kb/s, and intelligibility degrades gracefully at BER's up to 10E-2. A disadvantage of LPC, and the other parametric techniques, is the relatively long processing delay required (>10 msec). The LPC-10 algorithm specified by the U.S. Department of Defense is an emerging standard in this area. Although all LPC algorithms are complex, two or three VLSI chips are sufficient to implement most codecs.

A common and simple method of improving the error sensitivity of parametric coders is known as error concealment. For instance, LPC coders produce data in blocks, and it is straightforward to add a block checksum code. If an error is detected in the decoder then the contents of the block are disregarded and the parameter update is done by interpolation of previous values instead. The robust BER performance that results is one of the reasons LPC is popular in military applications.

Some of the waveform and parametric coders produce data in segments, with several segments per update block, and each segment contributing an incremental improvement in speech quality. These "embedded coders" allow dynamic selection of channel bit rate and the corresponding quality of service. An external controller can input the full data rate from a coder and delete segments to reduce the transmitted information when the traffic load is heavy. The controller can treat subscribers with different priorities and service requirements differently. Embedded coding algorithms exist for SBC, ATC, and LPC among others.

SCPC system efficiency can be improved by the use of Voice Activity Detection (VAD) to burst the carrier only when voice is present. In digital SCPC systems, VAD can be produced by analyzing the speech energy level, envelope slope, zero crossing rate, or other parameters. When using ADPCM and ADM codecs, a simple but effective method is to compare the adaptive quantizer step size with a preset threshold value. To avoid confusion of the listener when using burst transmission, simulated idle noise may be added to the telephone earpiece between received bursts. The use of VAD bursting can easily reduce transponder power use by over 50%.

The number of options available for speech coding in digital SCPC systems is large and growing. This is a great advantage over analog systems because the baseband voice processing can be optimized to produce the performance required by the subscribers at the minimum possible transponder usage. Even though the speech codecs can become very complex, implementations using DSP and VLSI are compact and cost effective.

Processing to remove echos is necessary in most SCPC network applications. Echos are caused by impedance mismatches at the interface between 4-wire and 2-wire telephone circuits, and even low amplitude echos are made subjectively objectionable by the long round-trip delays involved in satellite communications. A simple solution used on terrestrial circuits is echo suppression, which entails blocking received noises when a person is talking. This method results in confusion when both people talk simultaneously with long delay paths. The preferred method is to use an echo canceller, which only affects the echo signal, allowing speech to go both ways. This is accomplished by using a complex adaptive digital filter to detect echos, estimate their characteristics, and filter out later occurrences. Normally, echos will only be noticed for a few seconds at the beginning of a conversation when echo cancelling is used. VLSI echo canceller chips are now available at low cost.

This concludes the description of options available for the digital processing of baseband voice and data prior to transmission over an SCPC channel. The advantages of the digital approach to SCPC networks should be clear.

STATUS OF DIGITAL SCPC SYSTEMS IN CANADA

Canada entered into the arena of domestic satellite communication systems through the formation of Telesat Canada in 1969 and became the first country in the world to operate a domestic synchronous satellite system in 1972.

A state-of-the-art digital SCPC system, SPACETEL (5 and 6), was designed and built by Microtel to enhance existing communications services as well as to allow services not previously available.

A SPACETEL system has been in operation within the British Columbia Telephone Company (B.C. Tel) serving the western-most province of Canada since early 1984. One of the main applications in B.C. for SPACETEL is the primary resource area. The two major industries in British Columbia are mining and forestry. Activities related to these sections, such as logging camps and geological survey camps, tend to be temporary in nature, lasting anywhere from several months to perhaps a year or two. These industries have provided challenges for the operating company with respect to both voice and data services. The installation of terrestrial service over mountainous terrain, to locations completely isolated from any form of civilization, for a temporary period of time, is simply not economical. As well, offshore oil exploration on the West Coast is beginning to show promise, and will no doubt put similar business pressure on the operating company. Emergency restoral of service is an other application where SPACETEL, through its small and portable ground stations, offers unique flexibility and convenience.

To date B.C. Tel has installed the SPACETEL system to extend urban quality service to many remote resource based commercial work sites. SPACETEL provides high quality voice and data communications from small remotes (down to 1.8 meter antennas) and connects these to the voice and data networks through a larger Master Control Station.

The B.C. Tel system was first installed to operate in a Preassigned Mode where each user is given a dedicated frequency channel slot. During the first quarter of 1985, a Demand Assigned subsystem will be equipped at the master station and allow channel frequency assignment on a demand basis giving improved utilization of the space segment. All remote terminals are equipped for operation in either PAMA or DAMA mode when shipped from the factory.

The Master Control Station includes all the functionality needed by the operator's personnel to carry out a variety of maintenance and test functions. In a large SCPC system with many stations in highly remote and isolated locations, these functions are of great importance for efficient network operation. SPACETEL can automatically verify the performance of the stations connected to it and will report non-responding or failed stations to the maintenance personnel. The MCS also records all system usage, displays MCS equipment failures and control equipment redundancies.

Manitoba Telephone Systems (MTS) has installed a Master Control Station in Winnipeg, the provincial capital in that prairie province. Like the B.C. Tel system, it operates over the Anik C satellite at 14/12 GHz (Ku-band). The major application is to provide public telephone service to remote northern communities. Approximately half a dozen locations are included in the initial installation.

The Department of Communications of the Canadian Federal Government will shortly install a SPACETEL system for a trial on appropriate applications of a digital SCPC communications system within various government agencies. The initial trial will include unmanned lighthouses, remote border crossings and outlying radar installations.

Telephone communications in the western part of the Canadian Far North is served by NorthwesTel, where a 6/4 GHz SPACETEL system is to be installed in early 1985. Communication requirements in this part of Canada include remote villages, as well as resource development camps.

SPACETEL is now well integrated into the Canadian public telephone network and also provides high quality data communications to remote locations. As the Canadian regulations on ownership of earth stations move toward private ownership in steps during 1985 and 1986, it is fully expected that SPACETEL will find several applications in highly dispersed corporate voice and data networks.

CONCLUSIONS

A number of factors affecting the choice of technology for an SCPC Satellite Network have been discussed, clearly indicating the advantages of a digital implementation. Ongoing developments in digital processing promise significant further improvements and advantages for digital systems, affecting both new installations and also allowing upgrading of existing digital installations.

Applications of the SPACETEL digital SCPC communication systems in the Canadian network show the practicality and economic justification of these systems in a competitive environment.

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State of the Art SCPC Satellite Communications Systems

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1. Abstract

SCPC satellite communications systems are now widely used in International and Domestic systems for telephone and data networks, using various types of analog or digital modulation techniques to meet the particular requirements of the network service, system configuration and investment. Digital modulation techniques are now rapidly being developed, applying theoretical and LSI hardware technologies, and have been introduced in the Japanese Domsat System.

2. INTRODUCTION

SCPC Satellite Communications Systems have been widely used in the past ten years, to provide thin route international and domestic satellite communications services.

The main reason of this progress is due to the development of modulation and digital processing techniques, especially, voice coding, video coding, data FEC coding and DAMA control, which have all provided efficient SCPC transmission systems of high quality, utilizing a limited transmitting power and bandwidth. Another reason is due to the production of economical earth station equipment which is compact, has a low-power consumption and is reliable, allowing direct transmit and receive access from user's premises in the C, Ku and Ka frequency bands.

This paper describes the state of the art SCPC satellite communications systems for C, Ku and Ka bands and the following items are discussed: (1) Present SCPC system, (2) SCPC analog and digital modulation techniques and FEC performance, and (3) SCPC system applications in the Japanese CS-2 Ka-band satellite system.

3. OVERVIEW OF SCPC SATELLITE COMMUNICATION SYSTEM

The main feature of an SCPC satellite communication system is its flexibility to handle various types of services, changing traffic capacities and other communication requirements. In other words, an optimum communication network configuration can be achieved in accordance with basic system parameters, such as the available satellite transponder, earth station characteristics and system control and channel modulation techniques.

At the same time, an SCPC system can easily cope with further network expansions, increased traffic capacity or introduction of new services, without affecting the compatibility of the existing system operation. It is for these reasons that SCPC satellite communication systems have been widely adopted by both international Intelsat and Inmarsat communication networks, and many Domsat systems. Table 3-1 shows some typical existing SCPC systems, and a summary of the main features of the SCPC system configurations and operating conditions.

The basic SCPC earth station configuration is divided into four blocks as shown in Fig.3-1; (1) ANT/RF Terminal, (2) RF/IF Common Unit, (3) Analog or Digital Channel Unit, and (4) Satellite Control and Terrestrial Interface Unit. Photo 1 and 2 show two typical SCPC ANT/RF terminals for a Domsat System application. The ANT, HPA and LNA combination is selected from the viewpoints of providing the most economical and reliable hardwave configuration to satisfy the required G/T and EIRP of the system. Recently, a compact and maintenance-free SCPC ANT/RF terminal, for installation at a user's premises, has been realized by developing a compact RF unit using solid state devices for the low noise converter (LNC) and high power converter (HPC).

The choice of analog or digital channel modulation techniques, depends on the system operational requirements. In case of a public telephone network application, a companded FM (CFM) system is a practical solution from a viewpoint of over-all system investment. On the other hand, considering the possibility of future new digital services, a digital channel configuration is also desirable. A detailed description is provided in Section 4 and 5.

Demand Assignment Multiple Access (DAMA) and Transmit Power Control (TPC) control techniques are essential in an SCPC system in order to efficiently utilize the satellite transponder. DAMA can significantly increase the efficiency of available satellite channels and TPC improves the system availability by compensating for attenuation due to rain-fall in the Ku and Ka bands. A practical DAMA terminal with a TPC technique has been introduced in the Japanese CS-2 domestic system and is described in Section 6 and reference [1], respectively.

Table 3-1 Present SCPC System

System	Intelsat			Inmarsat	Domsat			
Frequency (GHz)	6/4			1.6/1.5	14/12 Australian HTSS		30/20 Japanese CS-2	
Earth Station Type	STD-A	STD-B	STD-D	STD-A	Master	Remote	Master	Remote or Mobile
Antenna mφ	30	11~13	D1 D2 4.5/13	1.2	6.4	3.0~6.4	5	2~5
G/T dB/K	40.7	31.7	22.7/31.7	-4	31	25~31	31	24~31
EIRP dBW/CH	63.0/69.8	63.0/69.8	56.6/52.7	36	45~51	44~50	52~60	52~60
Channel Operation Mode								
ch. Spacing. (kHz)	45		45	25	22.5		45	
Modulation	Q-PSK		FM	FM	FM		FM/Q-PSK	
Voice	PCM A-law		2:1 Syllabic	2:1 Syllabic	2:1 Syllabic		2:1 Syllabic/ADPCM	
Data	48,50,56kbps with FEC		——	Telex data 4.8 kbps	2.048 Mbps with FEC		16kbps~1.2Mbps with FEC	
System Control Mode	DAMA(SPADE) & PAMA.	PAMA	PAMA	DAMA	DAMA. TPC.		DAMA/PAMA TPC.	
Type of Service	International Telephony & High Speed Data.		International Telephony	Marintime Telephony & Telex	Remote Area Telephony & High Speed Data		Emergency Telephony & New Services such as TV-conferencing.	

DAMA: Demand Assignment Multiple Access.
PAMA: Pre-Assign Multiple Access.
TPC: Transmit Power Control.

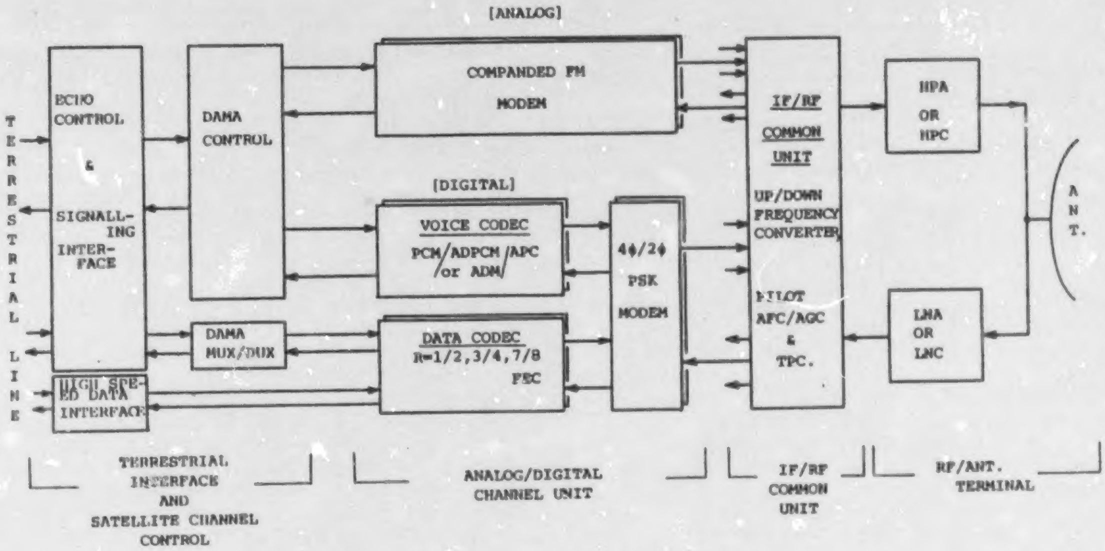
[ANALOG]
COMPANDED FM MODEM
[DIGITAL]
VOICE CODEC
PCM/ADPCM/APC or ADM
DATA CODEC
R=1/2,3/4,7/8 FEC
4φ/2φ PSK MODEM
TERRESTRIAL LINE
ECHO CONTROL & SIGNALLING INTERFACE
DAMA CONTROL
DAMA MUX/DUX
HIGH SPEED DATA INTERFACE
IF/RF COMMON UNIT
UP/DOWN FREQUENCY CONVERTER
PILOT AFC/AGC & TPC.
HPA OR HPC
LNA OR LNC
ANT.
TERRESTRIAL INTERFACE AND SATELLITE CHANNEL CONTROL
ANALOG/DIGITAL CHANNEL UNIT
IF/RF COMMON UNIT
RF/ANT. TERMINAL

Fig.3-1 Typical SCPC Earth Station Configuration

4. CONSIDERATION OF ANALOG AND DIGITAL MODULATION TECHNIQUES

In the SCPC System design, the channel spacing and threshold C/No (Carrier-to-noise density ratio) are key factors in the selection of the channel modulation techniques. This means that with a small transmission bandwidth and a low threshold C/No a large number of channels can be transmitted through a satellite transponder. Following analog and digital channel modulation techniques are compared with each other, for their respective voice and data transmission performance.

1) Analog Modulation:

- Companded Frequency Modulation (CFM)
- 2 : 1 Syllabic companding
- rms test tone deviation for 0 dBm0 at 1 KHz;

  3.4 KHz for 22.5 KHz channel spacing,

  5.3 KHz for 30 KHz channel spacing, and

  6.8 KHz for 45 KHz channel spacing.

2) Digital Modulation:

- Voice Coding,

  64 Kb/s PCM

  32 Kb/s Adaptive Differential PCM (ADPCM), [2]

  16 Kb/s Adaptive Predictive Coding (APC), [3]

- 4 Phase PSK Modulation and Coherent Demodulation.
- Forward Error correction (FEC) is employed.

Fig.4-1 and Fig.4-2 show voice and data transmission performance, respectively, with other characteristics summarized in Table 4-1.

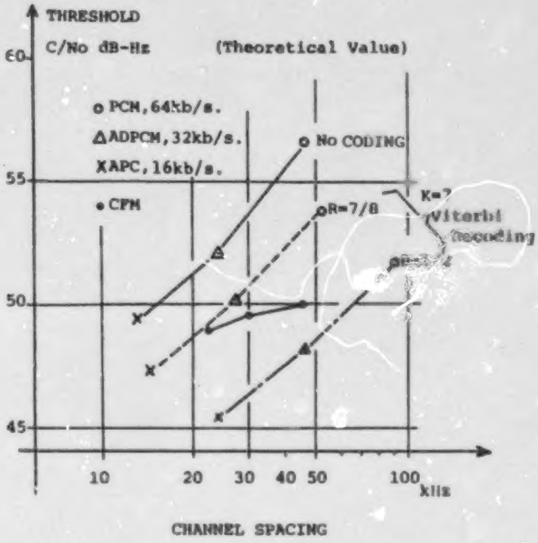

Fig.4-1 Voice Transmission Performance for Various Modulation Techniques

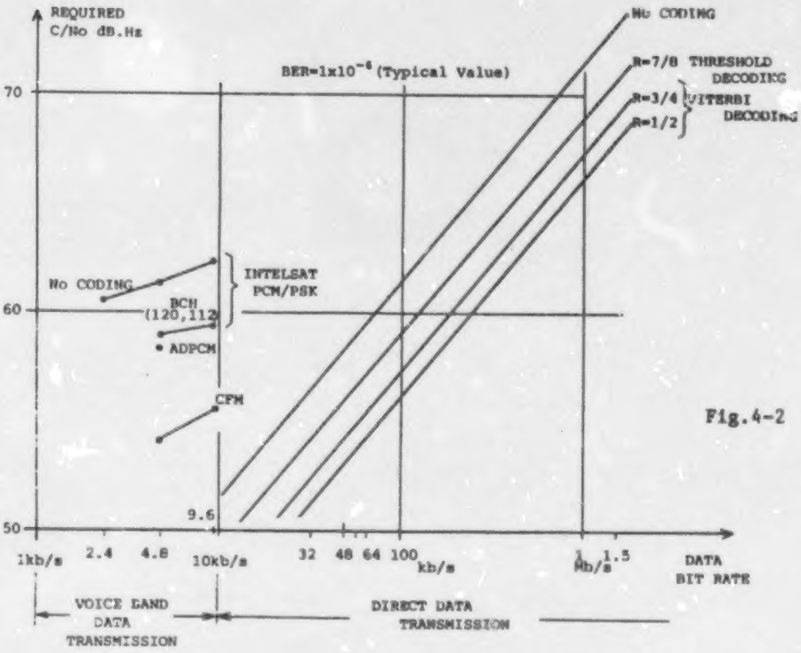

Fig.4-2 Data Transmission Performance for Various Coding Techniques

Table 4-1 Technical Comparison of FM and Digital

Modulation Performance	Companded FM	Digital PSK		
		PCM 64kb/s	ADPCM 32kb/s	APC 16kb/s
Threshokd C/No for Voice Transmission. *No Coding (Theretical) **R=1/2,K=7 Viterbi Decoding (Theoretical)	50dB.Hz (T.T. Deviation:6.8kHz.r.m.s Transmitting BW:30.4kHz)	*56.6dB.Hz (BER:$1x10^{-4}$) **51.7dB.Hz	*52.1dB.Hz (BER:$1x10^{-4}$) **40.2dB.Hz	*49.4dB.Hz (BER:$1x10^{-3}$) **45.4dB.Hz
Transmission Quality Voice	Full Toll Quality	Full Toll Quality (CCITT G.712)	Full Toll Quality (CCITT G.712)	Communication Quality
Voice-Band Data	~9.6kb/s	~9.6kb/s	~4.8kb/s	
Direct Digital Data	Not Capable	Capable of transmitting a high speed data, using a FEC technique of R=1/2 or 3/4 or 7/8.		
Other Applications Signalling Transmission	In-Band or Out-of-Band. (3825 HZ)	In-Band or Digital Multiplexed Out-of-Band.		
Encryption	Complex.	DES or similer type method is easily applicable.		

As shown in these results, CFM is superior to PCM both in terms of channel spacing and threshold C/No. However, ADPCM which has almost the same voice transmission quality of CCITT G.712, shows similar performances to CFM, using an FEC technique. APC is a most effective channel technique for voice transmission, and can therefore be expected to be introduced in the future Inmarsat system and other rural communication systems which require a limited voice quality service.

The greatest advantage of a digital modulation technique is the capability to transmit direct high speed data, compared with voice band data transmission used in a CFM system. On the other hand, hardware design has to take into consideration the carrier frequency offset, phase noise and other performance requirements of the actual system design. Table 4-2 shows some of these considerations.

These are general considerations for SCPC Analog and Digital modulation techniques. The choice of Analog or Digital modulation should be determined by the system requirements. An Analog system will be most suitable for a public telephone network, and a Digital system will provide a more flexible mode of operation for both voice and data transmission.

Table 4-2 Hardware Design Impacts for Various Factors

Modulation Factor	FM	PSK
Carrier Freq.Offset (Burst Mode Operation)	Less than ±2~3kHz	Less than $\frac{1}{16}$ X (Transmission Symbol Rate)
RF Local OSC Phase Noise (at 1kHz offset point)	Less than 75dBc (100pwp,S/N Contribution)	Less than 60dBc (Negligible for BER: $1x10^{-7}$)
Hardware Design In-completeness ·CH Filter. ·Phase Lock Loop. ·Frequency Drift of OSC's. ·Gain and DC offset.	0.5~1dB Impact from a theoretical value.	1~1.5dB Impact from a theoretival value.
IC or LSI Technique	Analog IC and Hybrid IC.	Digital LSI or Digital Signal Processor.

5. ADVANCED DIGITAL MODULATION TECHNIQUES

5.1 FORWARD ERROR CORRECTION (FEC)

In a satellite communications system, efficient utilization of satellite power is a key factor, and forward error correction (FEC) is often used to achieve this. When FEC is utilized, expansion of the transmission band width, due to addition of parity bits, is required but its coding gain outweighs the disadvantage of the expanded band width. Typical FEC and decoding algorithms, used in existing satellite communication systems, are BCH code, self-orthogonal coding/threshold decoding, convolutional coding/sequential decoding, and convolutional coding/Viterbi decoding. A comparison of these methods is shown in Fig.5-1.

The BCH and self-orthogonal code are relatively easy to implement, and they have been widely used, but a large coding gain can not be obtained with these techniques. On the other hand, sequential decoding and Viterbi decoding are decoding schemes which provide an extremely high coding gain, but in the past have not always been easy to implement. However, recently, with the advances in LSI technology, implementation has become easier, and Viterbi decoding is now specified for Intelsat IBS and other systems.

Sequential decoders provide a very large gain for bit error rates below 10^{-5}, but operation at a higher BER is unstable, which means that the technique is only suited to low BER systems for data transmission and not suited to voice transmission with higher BER thresholds (10^{-3} to 10^{-4}).

Viterbi decoding is slightly inferior to sequential decoding, as far as coding gain for a low BER, but shows superior performance in a high BER application and is the best decoding algorithm for voice transmission. The practical coding rate (R) of a Viterbi decoding system has only been 1/2, because the hardware for other coding rates using this technique is very complex. However, by making use of a punctured code recently introduced [4], decoders with an R of 3/4 or 7/8 can be easily built (See Fig.5-2).

Also, when the information rate is about 10M bps or less, CMOS LSI technique can be employed, so that compact and low cost Viterbi decoders can be realized.

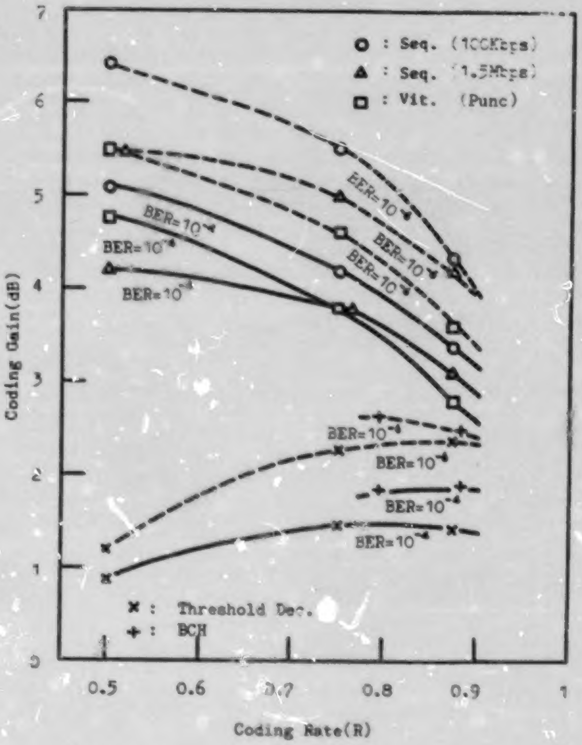

Fig.5-1 Comparison of Coding/Decoding Schemes

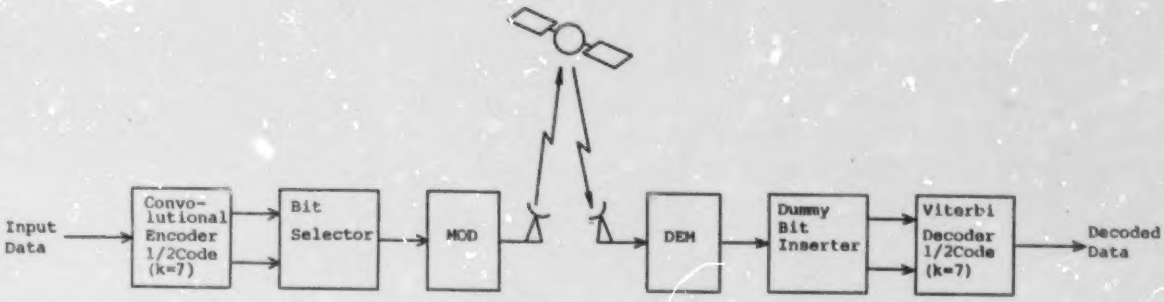
Input Data
Convo-lutional Encoder 1/2Code (k=7)
Bit Selector
MOD
DEM
Dummy Bit Inserter
Viterbi Decoder 1/2Code (k=7)
Decoded Data

Fig.5-2 Functional Block Diagram of Variable-Rate Viterbi Decoder

5.2 MODULATOR AND DEMODULATOR

PSK, MSK, FSK, and ASK digital modulation schemes are available, but PSK and MSK are more suited to digital SCPC systems because of their performance and occupied bandwidth. The difference between PSK and MSK performance is very small, and they should be selected depending on the particular application. Usually PSK, with its relatively simple hardware, is used provided there is no specific reason such as non-linearity in the transmission path.

In a PSK signal demodulation system, the coherent detection is excellent because its performance is very high. Coherent detection is often realized with differential coding because of the simple hardware. However when FEC is used, the performance is degraded due to a double error which is generated by differential coding. In order to avoid the double error, absolute phase coherent detection is recommended as the best demodulation system.

In this detection method, if phase slip of the recovered carrier occurs, a burst error is generated and the performance is badly degraded. Moreover, if FEC is used, it is necessary to provide stable operation under extremely low C/N conditions, which may possibly cause more frequent phase slips. Because of these reasons, the bandwidth for the carrier recovery circuit should be as narrow as possible. Frequency fluctuation and phase noise from the frequency converter local oscillator will also seriously degrade the demodulator performance, therefore careful attention should be paid to the design of the carrier recovery circuit.

In SCPC systems, voice activated burst operation is employed, but, when the preamble word length at the start of the burst is short, a wide band carrier recovery circuit is required to achieve fast carrier acquisition, which is contrary to the condition described above. Ordinarily, the occupation rate of the preamble bits is far shorter than that of the information bits, therefore it is not necessary to make it as short as the preamble length (carrier 20 bits, clock 40 bits) employed in the Intelsat SCPC system. It should be set as long as possible (10m sec - 20m sec) provided the propagation delay (about 300m sec) is not affected.

The SCPC demodulator, described above, for burst operation, requires more complicated hardware than a continuous mode demodulator, and has many factors which will make the operation unstable. In order to solve these problems, research has recently been directed at producing a digitalized demodulator. (Fig.5-3). SCPC systems, where the transmission speed is low, are idealy suited to digitalization. A demodulator of about 100K bps or less makes the introduction of CMOS LSI technology possible and, as in FEC decoders, compact, low cost, highly stable digital modems will soon be available.

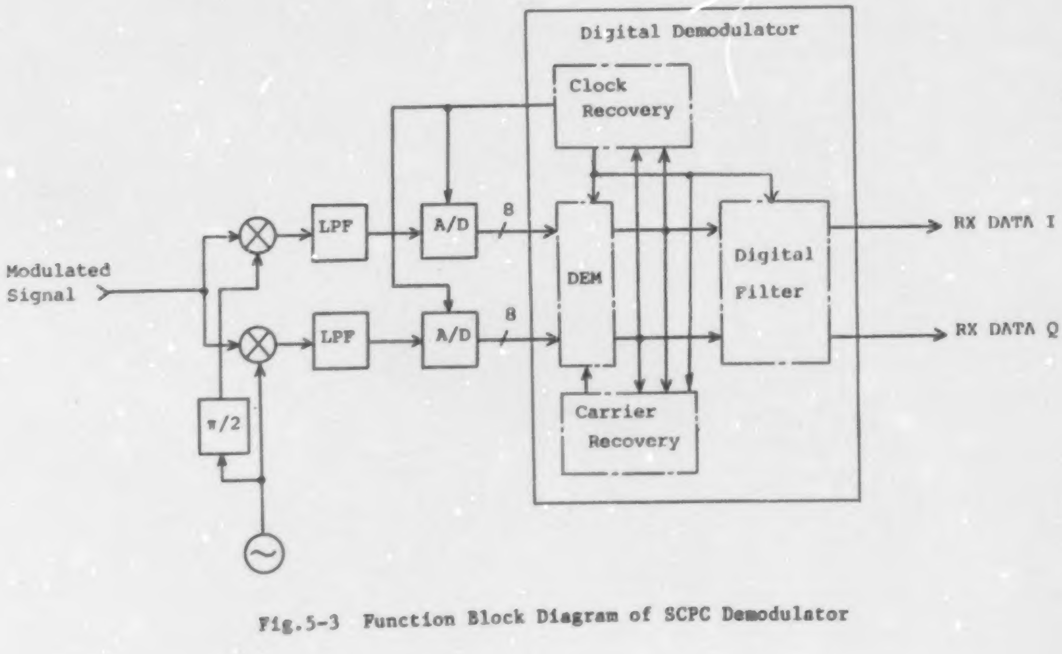

Fig.5-3 Function Block Diagram of SCPC Demodulator

6. SCPC SYSTEM APPLICATIONS IN THE JAPANESE CS-2 Ka-BAND SATELLITE

The first Japanese practical communication satellite (CS-2a or Sakura-2a) was launched successfully in February, 1983 and has been in operational use from June, 1983. A second satellite (CS-2b or Sakura-2B) was launched in August, 1983 and is now operational as a redundant satellite. Each satellite has eight transponders, two at C-band and six at K-band. Of the six K-band transponders, four transponders are utilized by the Nippon Telegraph and Telephone Public Corp. (NTT) and one is used by the National Police Agency (NPA). The last one is operated by several users, such as government offices and public enterprises. Frequency allocations for the shared transponder are shown in Fig.6-1.

In this section, the following systems are introduced.

(1) TV and digital SCPC terminal equipment for the NPA system using one full transponder.

(2) FM-SCPC terminal equipment with a DAMA function for the system of electric power companies using a co-operational transponder unit 4 (lower band).

(3) Digital terminal equipment for TV conference for the Japanese National Railways' (JNR) system using the same unit 4 (upper band).

6.1 TV AND DIGITAL SCPC TERMINAL EQUIPMENT

Fig.6-2 and Photo 3 show the configuration and appearance of the terminal equipment for a transportable station. The station transmits and receives video and around 10 telephone channels. A conventional FM modem with an audio sub-carrier is used for the video transmission and a digital SCPC system is used for the telephony transmission. A new 32 kbps ADPCM voice coding system is introduced for the digital channel and the 32 kbps digital stream is converted to a 33.3 kbps transmission rate by adding the synchronization words for burst mode operation and ADPCM word synchronization.

A two phase PSK modem is used for this transmission in order to minimize the degradation due to the carrier-offset and phase noise characteristics of the RF and Satellite local oscillators. A pulse mode transmission method is used for the telephony signalling data transmission, which does not affect the SCPC voice activation operation, and it is used in a single frequency (2300 Hz) mode.

As shown in Photo 3, the terminal is designed as a transportable station, with each unit capable of being removed from the rack and set up on a desk for quick operation.

6.2 FM-SCPC TERMINAL EQUIPMENT WITH DAMA FUNCTION

A Block diagram of an FM-SCPC terminal with DAMA, and the central station equipment are shown in Fig.6-3 and Photo 4. This satellite communications system is used throughout Japan, with the SCPC system using FM modulation for telephony transmission and a DAMA (Demand Assignment Multiple Access) control.

In existing systems, DAMA Signalling data transmission is generally independent from voice transmission. But, in this system, by using an FM modulator/demodulator unit for both voice transmission and signalling data transmission, the terminal equipment configuration can be simplified. The following functions have been developed for this purpose.

(1) 2 error and 3 error detection by BCH (61, 48) as the error control system for data transmission

(2) Control of Packet transmission timing at each local station according to the received carrier from the central station

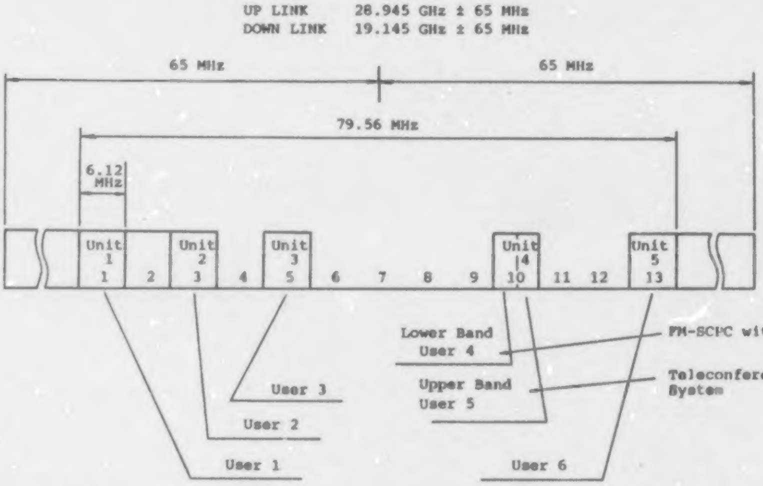

Fig.6-1 Frequency Allocation of Co-operational Transponder

(3) Synchronous word detection from data received from the central station

(4) Data format conversion from the data terminal to the satellite data transmission route

(5) 1,200 bps FSK MODEM for data transmission

(1) to (4) are software processing functions using a microprocessor.

The terminal configuration has a Central DAMA Control Unit at the central station and a DAMA Terminal Control Unit of each channel at the local stations for DAMA signalling transmission. This data channel is also used for transmission of various control and monitor data from each earth station.

6.3 DIGITAL TERMINAL EQUIPMENT FOR TV CONFERENCE

The terminal equipment for a satellite communications TV conference system is complicated because various, motion picture, still picture, voice and control signals must be transmitted. The block diagram and the digital terminal for teleconferencing are shown in Fig.6-4 and Photo 5.

A key factor in achieving such a satellite communications system is the ability to transmit as much information as possible with limited satellite power. The first step is to minimize the transmission bit rate for the various data. In this system, the transmission bit rate, for a motion picture signal, is 1.2 Mbps using a codec with an advanced data compression of predictive coding technique, and the audio, in a 6 KHz bandwidth, is coded at 64K bps using ADPCM.

The second step is to transmit this data through a satellite circuit using as little power as possible. In this case, generation of data error due to noise in satellite path is a problem, and therefore use of an effective error control system is essential. An error correction system using a convolution coding/Viterbi decoding method with a coding rate of 1/2 has been developed for practical use, which decreases the required carrier power by 1/3 or more compared with systems without an error correction function.

Furthermore, the use of DAMA control in the system, allows the limited number of satellite carriers to be shared by many more stations. The CSC (Common Signalling Channel) is used for transmitting information for the conference and control related equipment. The CMP (Conference Management Processor), utilizing personal computers in the conference room, is the man-machine interface for the TV conference and data from the CMP is connected to the LMP (Line Management Processor) in the terminal equipment. This control data is then sent through the satellite circuit, in a continuous TDM carrier using a broadcasting mode, from a central station to each local station. One carrier is shared, using a slotted random access system, for data transmission from each local station to the central station. The LMP also controls the carrier frequency changes in the communications equipment. The various transmission signals, used in this system, are shown in Table 6-1.

7. CONCLUSION

The key technologies in an SCPC system are the channel modulation and system control techniques. Recent analog and digital modem techniques, using LSI's and microprocessors, have been incorporated with the SCPC hardware design. The latest analog channel of an FM system is capable of operating in an alternate voice and data mode in a DAMA system. Cost-effective FM-SCPC systems, with DAMA, are clearly now a practical choice for a telephony service network and are being adopted in the Australian and Japanese Domsat Systems.

In digital channel technology, low-bit rate speech encoding, FEC and digital modem techniques are a very useful way of saving transmit carrier power and bandwidth. In addition to these, a direct data transmission capability is a very significant advantage, especially for high speed data transmission needed for high quality data or video services. We expect that SCPC systems will be rapidly introduced in thin route Domsat systems and that new analog and digital services will be expanded to rural areas using advanced channel and system control technology.

8. ACKNOWLEDGEMENT

The authors wish to thank Messers. S. Yokoyama, M. Kajikawa and I. Haga of Microwave and Satellite Communications Division for their useful suggestions and guidances to develop the system and hardwares.

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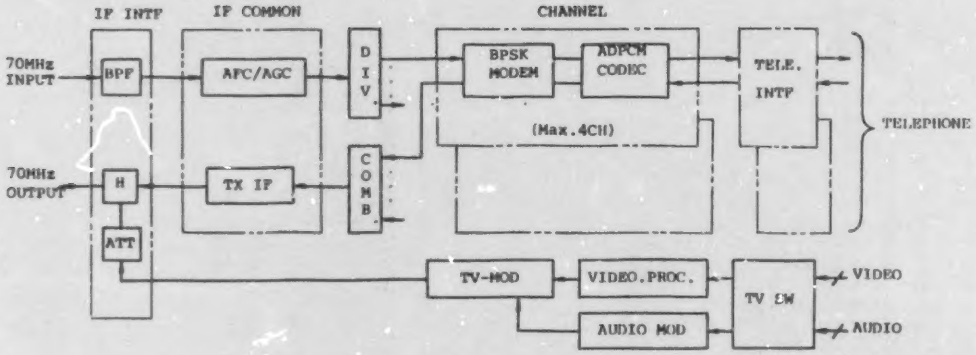
IF INTF
IF COMMON
CHANNEL
70MHz INPUT
BPF
AFC/AGC
DIV
BPSK MODEM
ADPCM CODEC
TELE. INTF
TELEPHONE
(Max.4CH)
70MHz OUTPUT
H
TX IF
COMB
ATT
TV-MOD
VIDEO.PROC.
TV SW
VIDEO
AUDIO MOD
AUDIO

Fig.6-2 Block diagram of TV and digital SCPC terminal equipment

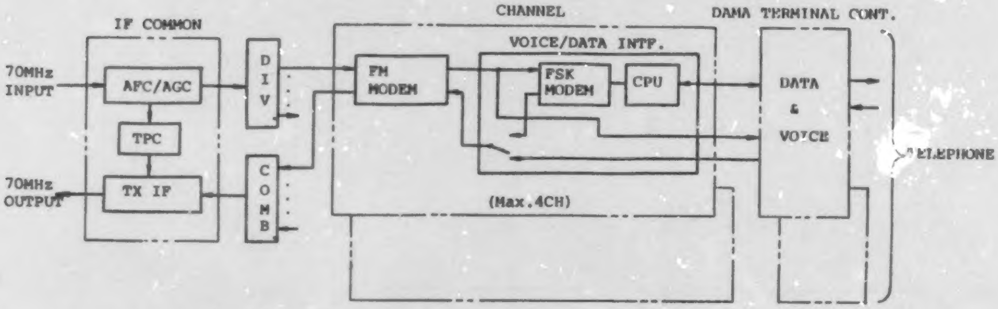
IF COMMON
CHANNEL
DAMA TERMINAL CONT.
VOICE/DATA INTF.
70MHz INPUT
AFC/AGC
DIV
FM MODEM
FSK MODEM
CPU
DATA & VOICE
TPC
TELEPHONE
70MHz OUTPUT
TX IF
COMB
(Max.4CH)

Fig.6-3 Block diagram of FM-SCPC terminal equipment with DAMA function

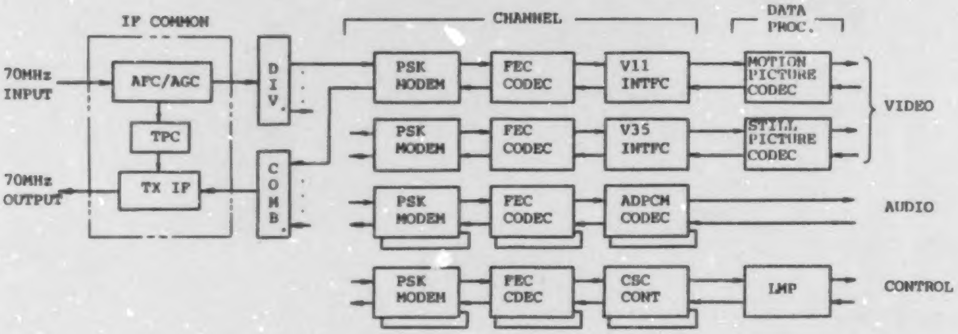
IF COMMON
CHANNEL
DATA PROC.
70MHz INPUT
AFC/AGC
DIV
PSK MODEM
FEC CODEC
V11 INTFC
MOTION PICTURE CODEC
VIDEO
TPC
PSK MODEM
FEC CODEC
V35 INTFC
STILL PICTURE CODEC
70MHz OUTPUT
TX IF
COMB
PSK MODEM
FEC CODEC
ADPCM CODEC
AUDIO
PSK MODEM
FEC CDEC
CSC CONT
LMP
CONTROL

Fig.6-4 Block diagram of digital terminal equipment or teleconferencing

Table 6-1 Transmission signals of terminal for teleconferencing

Signal Name	Circuit Number	Information Rate	Transmission Rate	Modulation	Control Mode	Note
TV(Motion Picture)	1	1.2Mbps	2.4Mbps	4ϕPSK	DAMA	NETEC
TV(Still Picture)	1	64kbps	128kbps			TVS
Audio	3	64kbps	128kbps			ADPCM
CSC-1	1	32kbps	64kbps	2ϕPSK	Pre-Assigned TDM	Central ← Local
CSC-2	1	16kbps	32kbps		Random Access Slotted Aloha Packet	Local → Central

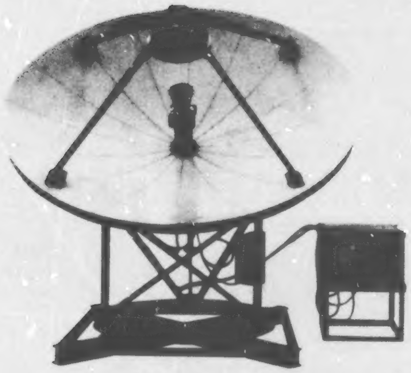

Photo 1 3.3 mϕ ANT/RF Terminal
for a 14/12 GHz Domsat Remote System.

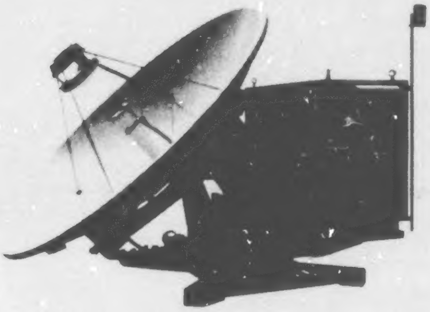

Photo 2 3 mϕ ANT/RF Terminal
for a 30/20 GHz Domsat Remote System.

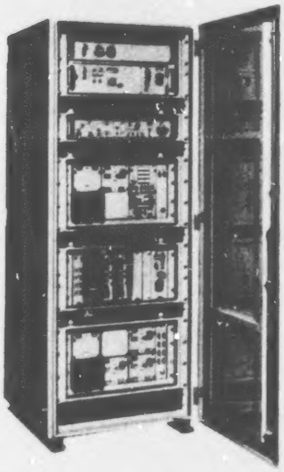

Photo 3 Transportable Digital SCPC Terminal

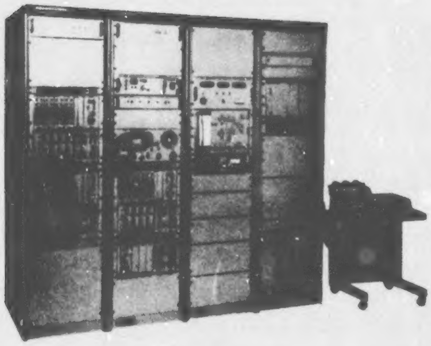

Photo 4 FM-SCPC Terminal Equipment
with DAMA Function
for Central Station

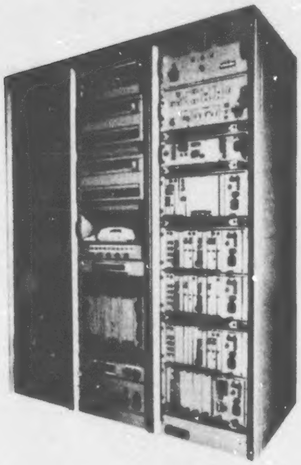

Photo 5 Digital Terminal Equipment
for Teleconferencing

BEST COPY AVAILABLE

Application of Digital and Lightwave Technology to Undersea Communications

J. M. Sipress
AT&T Bell Laboratories
Holmdel, New Jersey

1. ABSTRACT

The rapid advances in digital and lightwave technology permit the realization of significantly new communications capability via undersea cable systems. Digital lightwave systems provide a cost-effective method for spanning oceans as typified by the planned new transpacific cable. At the other extreme, unrepeatered lightwave systems, approaching 200 km in length, can provide for communications across channels, between islands and to offshore islands and structures without any underwater electronics. New network configurations and new services are also possible. This paper discusses these new capabilities, the technology, and planned and proposed applications.

2. INTRODUCTION

The use of undersea cables to penetrate the communications barrier of bodies of water has a long history. A telegraph cable was successfully deployed across the Atlantic in 1866. Deep water coaxial cables for voice communications were deployed almost 35 years ago and spanned the Pacific Ocean in 1964. The early coaxial installations provided only 36 voice channels, but steady advances in the technology led to systems which can now provide over 5000 channels. These improvements, however, required much larger cables, 43 mm in diameter compared to 16 mm in the early systems, and much shorter repeater spacings, 9 km compared to 70 km.

In addition, circuit multiplication technology, initially called TASI for Time Assignment Speech Interpolation, permitted the attainment of more than one virtual circuit from each actual circuit. Initially, these TASI systems were relatively expensive and permitted only a 2 to 1 ratio. Digital technology improvements led to modern TASI equipment which give a higher multiplication advantage, approximately 2.4 to 1, as well as being cost-effective on much shorter undersea routes.

The new lightwave technology can

- provide capacity greater than that of the newest coaxial systems with cable size and repeater spacing approaching that of the earliest designs
- already span bodies of water of almost 200 km without underwater electronics
- provide new broadband digital services
- allow for new networking configurations through the use of multiple lightguide pairs and underwater branching points.

The enhancements in the digital technology also permit circuit multiplication of more than twice that of the modern TASI equipment while proving in at much shorter distances.

3. LIGHTWAVE TECHNOLOGY

As in an analog coaxial system, the digital lightwave undersea system contains cable, repeaters, and terminals. In addition, the lightwave installations can incorporate branching equipment. Each of these will be discussed in turn.

3.1 CABLE AND LIGHTGUIDE

A typical cable consists of an optical core containing several lightguides, steel to protect the core and to provide strength, copper to provide a powering path for the repeaters and polyethylene to separate this powering path from the sea water.

The key characteristics of the lightguide are loss, dispersion and mechanical strength. The loss plays a predominant role in repeater spacing. The dispersion causes light of different wavelengths to travel at different speeds through the lightguide which in turn causes the information-carrying pulses to broaden. This effect can limit repeater spacing in certain cases. Mechanical strength is required in order for the lightguides to survive the rigors of deployment, operation and recovery from the deep ocean floor. Deep sea trials and other tests have been conducted over the last 3 years which show that the required strength, typically greater than 200,000 psi, can be obtained in routine manufacture.

For long-haul systems to be deployed over the next several years, transmission is at 1.3 μm, the so-called second transmission window. At this wavelength, losses approaching 0.4 dB/km can be routinely achieved. Fortunately, silica-based lightguides also exhibit zero dispersion in the vicinity of this wavelength. Thus repeater spacing is limited by the loss and distances of 50 km between repeaters are typical for operation at 300 Mb/s.

At 1.5 μm, the third transmission window, losses of approximately 0.2 dB/km can be achieved. Thus it would appear that repeater spacings of 100 km should be possible. Unfortunately, the dispersion at this wavelength currently limits transmission to less than approximately 100 Mb/s at such distances. Removal of this limitation requires lightwave technology which is not yet fully developed, e.g., lightguides with the dispersion zero shifted by careful design to the vicinity of 1.5 μm and/or lasers that provide a single wavelength of light as opposed to the multi-wavelength sources currently in use.

3.2 REPEATERS

The mechanical portion of the repeater technology for repeatered undersea lightwave systems tends to be based quite strongly on the proven technology from the earlier coaxial undersea systems. Pressure vessels and repeater-to-cable couplings and seals draw heavily from and in many instances use identical technology to that employed in the coaxial art. The electronics, of course, represents a major departure, although significant prior undersea art is used here also.

A lightwave undersea repeater contains several regenerators with each providing for one direction of transmission over a single lightguide. In concept, the regenerators are similar to those used in land-based systems. Each regenerator includes

- a receiver, typically an InGaAs PIN or a Ge APD detector diode coupled to a silicon integrated circuit (SIC), to convert the incoming optical pulse stream, after passing through the seals and splices, to an electrical stream
- several additional SIC's to provide amplification for the electrical signal (the amplifier); to extract, in combination with a surface acoustic wave (SAW) filter, a synchronization signal from the pulse stream (the clock extraction circuit); and to decide, in combination with the extracted clock signal, whether a pulse is present or absent (the decision circuit)
- a laser transmitter, typically an InGaAsP laser and one or more SIC's, to convert the reconstructed electrical pulse stream back to an optical stream for transmission to the next repeater.

In addition, the repeater contains electronics to provide a local power source and supervisory and fault locating capability. The latter typically provides an in-service indication of the regenerator error performance, the incoming optical signal level and the laser health.

Key to the reliability of the system is the reliability of the repeater electronics. Various methods are employed to obtain the 25-year lifetime expected of undersea systems. Many of these techniques are similar to those employed in the coaxial art, e.g., careful design and thorough design qualification, and extensive certification testing of individual components prior to use. These techniques lead to SIC's with expected reliability better than 0.5 FIT (0.5 failures in 10^9 hours) and laser lifetimes greater than one million hours. Other reliability techniques are relatively new to undersea communications, e.g., component redundancy. In certain system embodiments, redundant laser transmitters and/or redundant regenerators which can be switched in place of a failed or degraded primary transmitter and/or regenerator are employed to increase system reliability.

3.3 TERMINALS

The terminal of a repeatered system consists of three major equipments:

- a high voltage power plant to provide current to the undersea repeaters - up to 7500 volts at up to 1.6 amps is typical.
- a transmission terminal to interface between the electrical pulse streams in the cable landing station and the optical cable, and to provide maintenance and operations features including end-to-end performance monitoring.
- a supervisory terminal to monitor the health of the individual undersea regenerators and to control the switching of the redundant elements.

In an unrepeatered system, only the transmission terminal need be provided.

3.4 BRANCHING REPEATER

The ability to place several pairs of lightguides in a single cable permits a significant new networking capability with lightwave undersea systems, i.e., the ability to branch signals out of the cable to provide landings at more than two locations. Consequently, several different end-to-end transmission paths can be cost-effectively included within a single cable sheath.

The actual separation of the transmission paths is accomplished typically in a branching repeater. This special undersea equipment provides the mechanical and electrical functions, including regeneration and supervision, to permit three cables to interconnect. Also, capability can be provided within the branching repeater to permit continued operation over the two remaining cables if one should fail as well as switching of the actual transmission paths from the failed cable and onto the remaining operational cables.

4. CIRCUIT MULTIPLICATION TECHNOLOGY

The advances in digital circuit technology permit not only the use of digital transmission within the undersea environment, but also allow the realization of circuit multiplication equipment with much higher virtual circuit to actual circuit ratios than can be obtained with TASI-type equipment.

The most modern circuit multiplication systems for analog coaxial undersea use permit approximately a 2.4 to 1 ratio. For digital transmission, a 2 to 1 ratio for voice transmission is obtained simply by using an efficient 32 kb/s coding algorithm instead of the normal 64 kb/s PCM format. Even more efficient coding can be achieved, with the limit related to the transmission delay one is willing to accept in the coding equipment. When coupled with the signal detection and echo cancellation techniques of the most modern time assignment technology, a 6 to 1 ratio can be obtained in the absence of voiceband data. The actual ratio depends upon the amount of voiceband data and for planning purposes typically a ratio of between 4 to 1 and 5 to 1 is assumed. Application of these new circuit multiplication terminals provides as many channels over a single 140 Mb/s digital stream as can be obtained over the largest analog coaxial cable system.

5. TRIALS AND EXPERIMENTS

Critical to the development of technology for undersea lightwave communications are laboratory demonstrations and field trials. The former are used to probe the limits of the technology. Examples of results include:

- In 1982, transmission at 274 Mb/s and 1.3 μm over 101 km.
- In 1983, 45 Mb/s at 1.5 μm and 151 km with a multi-frequency laser, and at 1.5 μm with a single-frequency laser, 420 Mb/s at 161 km and 1000 Mb/s at 101 km.
- In 1984, 3 Mb/s at 202 km and 296 Mb/s at 150 km with 1.5 μm multi-frequency lasers (the latter demonstration with dispersion-shifted lightguide), and with 1.5 μm single-frequency, 420 Mb/s at 203 km and 2000 Mb/s at 130 km.

Although caution needs to be exercised in drawing conclusions from these demonstrations since they use carefully selected components and typically provide no margins, the results do point to future capability.

The field trials, however, are needed to test specific components and methodology which are planned for near-term deployment in actual service. Major tests to date tend to fall into two distinct categories, short-term deep water and relatively long-term shallow water efforts. Examples of the former include:

- In 1982, a trial by AT&T at a depth of 5500 meters of 18 km of active cable containing 12 lightguides and a repeater containing two 274 Mb/s regenerators. Overall system length tested was 109 km with a maximum repeater span of 55 km.
- In 1984, a trial by KDD at a depth of 7000 meters of 24 km of cable with 6 lightguides and two repeaters each containing two 280 Mb/s regenerators. Overall system length was 48 km and maximum repeater span 16 km.

Examples of longer term shallow water tests include:

- In 1982, a trial by NTT conducted as a loop from the Izu Peninsula southwest of Tokyo of a 45 km, 400 Mb/s system containing two repeaters. Maximum repeater spacing was 30 km and maximum depth was 1000 meters.
- In 1982, a trial by KDD conducted as a loop from the Ninomiya coaxial cable landing station of a 50 km, 280 Mb/s system also containing two repeaters. Maximum repeater spacing was also 30 km and maximum depth was 1300 meters.
- In 1983, a trial by the FPTT of an 80 km system between Port-Grimaud and Antibes in southern France. This installation contained two repeaters each with four 280 Mb/s regenerators. Maximum repeater spacing was 35 km and the maximum depth 1800 meters.

6. APPLICATIONS

Extensive application of undersea lightwave technology is now being planned. This includes short-haul unrepeatered systems, short-haul repeatered systems and long-haul systems.

An example of a short-haul unrepeatered link is a 147-km system to provide 3 Mb/s communication between a Pacific island and a semisubmersible floating platform. Service over this link is scheduled for the spring of 1985. Another example is a 40 km 400 Mb/s system between two of the Japanese islands which was installed in 1984.

Examples of the repeatered short-haul systems include:

- A 120 km AT&T SL system between two of the Canary Islands for CTNE. This will provide 560 Mb/s of capacity over two 280 Mb/s lightguide pairs. Deployment is scheduled for later this year.
- A 122 km STC NL1 system between the U.K. and Belgium. This will provide 840 Mb/s of capacity over three 280 Mb/s lightguide pairs. Deployment is also scheduled for later this year.
- A 390 km Submarcom S280 system between Marseilles and Corsica for the French PTT. This will also provide 560 Mb/s of capacity over two 280 Mb/s lightguide pairs. Deployment is scheduled for 1986.

The first of the long-haul systems will be TAT-8, a $335M, 6400 km transatlantic system providing 280 Mb/s paths between the U.S. and the U.K., the U.S. and France, and the U.K. and France. A branching repeater will be located on the European continental shelf to provide splitting of the transatlantic cable from Tuckerton, New Jersey, into separate cables into Widemouth, U.K., and Penmarch, France. The construction and maintenance agreement for this system was signed by 29 partners on June 15, 1984, and service is planned for June 30, 1988. A unique characteristic of this installation is the "wet connection". The system from Widemouth to the branching point will be an STC NL2 design, from Penmarch to the branching point a Submarcom S280, and remainder an AT&T SL 280.

In the final planning stage is a vast Pacific Basin network which includes

- HAW-4, a 4000 km system with two 280 Mb/s lightguide pairs between the U.S. states of California and Hawaii.
- TPC-3, an 8700 km system also with two 280 Mb/s lightguide pairs and connecting Hawaii, Guam and Honshu. An underwater branching point will be located near Marcus Island to permit a direct two-way 280 Mb/s path between each pair of locations.
- GP-2, an approximately 3000 km system with 140 Mb/s of capacity between Guam and the Philippines.
- Additional cables connecting the above locations to Hong Kong, Korea and Taiwan.

7. FUTURE

The age of cost-effective undersea lightwave digital communications has arrived. Long-haul systems to span oceans and unrepeatered systems of almost 150 km length are possible, are scheduled for deployment and should be part of network plans where new capacity and/or new digital services are required.

We are, however, just at the very beginning of this new technology. We can look forward to longer repeater spacings and lower costs made possible by

- higher power laser sources
- more extensive use of the 1.5 μm third transmission window
- coherent transmission with frequency modulation of single frequency laser light instead of the relatively inefficient on/off binary modulation currently used.
- new Halide glass systems operating at 2 μm and beyond with loss one or more orders of magnitude lower than that obtainable with today's silica-based glass.

Today we proudly talk about lightwave undersea systems with repeater spacings similar to that of the original analog coaxial designs. Some day we may come full circle and talk about spacings equal to that of the original telegraph cables - no repeaters at all.

LONG DISTANCE MULTIMODE FIBER OPTICS SYSTEMS EXPERIENCE AT HAWAIIAN TELEPHONE COMPANY

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Abstract

The transmission of bit rates greater than 45Mb/s over non-repeatered fiber optics systems, longer than 35Km became fairly simple with the single-mode fiber optics technique which became a practical technology since the latter part of 1983. Multimode fibers, on the other hand, present a multitude of problems not encountered with single-mode fibers. This paper describes an experiment to construct a repeaterless, 90Mb/s, telephone trunk system 35Km long, utilizing existing multimode, long-wavelength fiber optics cable.

INTRODUCTION

Due to the high cost of cable installation, almost every telephone company installs cables with many spare fibers to accommodate future growth. With the advent of single-mode technology (during the latter part of 1983), the multimode fibers suddenly became obsolete. There are still many short haul applications where the use of the multimode fiber would be a more practical solution than the use of the single-mode fiber. In large systems, it may be better to standardize on one type of fiber rather than dealing with a mix of single and multimode fibers. The experiment to be described may be of interest to those that already have long wavelength, multimode fibers in place and are planning to increase the non-repeatered length of the system.

BACKGROUND

In 1982, Hawaiian Telephone Company installed a 35Km, 45Mb/s, repeaterless, long-wavelength system between Wahiawa and Honolulu. Longer distances were spanned under ideal laboratory conditions, but to our knowledge this was the longest multimode working system until it was upgraded to 90Mb/s in October of 1984. A brief background in the development of the system will help the reader to appreciate the difficulty of developing a multimode system to span a distance of 35Km.

The system planning started in January 1981 when the longest working fiber optics system in existence was less than 20Km. We were extremely fortunate to have Corning Glass Works and Siecor Optical Cable participate in this experiment along with GTE Laboratories and GTE Service Corp. After the system parameters were determined, engineers from Corning had to develop a new recipe to produce the fiber required for this project. The fiber specification was rather stringent for the state-of-the-art in 1981. The fiber attenuation had to be less than 1dB/Km with a bandwidth of more than 1.0GHz/Km. This meant that the fiber attenuation before cabling had to be between .6 to .7db/Km because microbend losses would increase the attenuation to approximately .9dB/Km after cabling. Determination of bandwidth was a more difficult problem because the gamma factor to use for the modal exponent was not known.

Since a factor of .75 seemed to work fairly well at 850nm, it was used to estimate the required fiber bandwidth which was 1.3GHz/Km for a 90Mb/s system.

$$90\ \text{MHz X}\ (35\ \text{Km})^{.75} = 1295\ \text{MHz}$$

Corning Glass Works started drawing the fibers in July 1981, which was six months after the first meeting. The initial test showed that the fiber optics cable had an average attenuation of 1.0dB/Km with a bandwidth that was slightly better than 1.0GHz/Km. The first cables were delivered in November and experimental tests were conducted in December with fiber optics terminals that were developed at GTE Laboratories. The final system was installed in 1382 with production model terminals that were modified to meet the more rigid specifications for this system. The final end-to-end attenuation of the fibers varied over a range of 26 to 30dB's. This included all splice and connector losses. The average splice loss was .18dB. The average system margin at a bit error rate of $(10)^{-9}$ was 11.5dB which indicated that we had a very reliable system. The end-to-end bandwidth of the fibers were not measured because the measuring set was not available at the time.

This fiber optics cable is also used on a repeaterless 25Km, 90Mb/s system that has a system margin of 15dB. A 16Km broadcast quality video system was added on to this same cable in 1983. It has a system margin of 8.5dB. When we first activated the video system for a CBS network feed without telling anyone that it was being transmitted over a fiber optics cable (rather than the usual microwave link), CBS at the receiving end immediately noticed the improved video quality. This fiber optics cable was about the best cable that was commercially available at the time.

UPGRADING TO 90Mb

A few months after the 45Mb/s system was placed into service, unforseen growth in circuit requirements made it necessary to double the system capacity by upgrading it to 90Mb/s. Preliminary tests with a 90Mb/s terminal was encouraging as the system margins varied from 1.5dB to 5.3dB over the various fibers as shown in Table I.

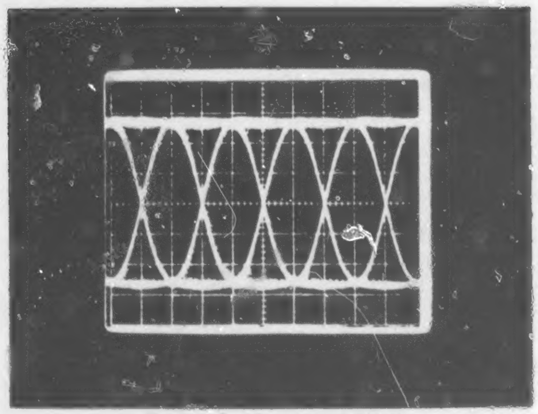
Table I
Initial 90Mb Transmission Test
East to West Direction

Fiber No.	Received Power	Minimum Received Power for 10^{-9} BER	System Margin
1	-31 dBm	-35.5 dBm	4.4 dB
2	-30.4 dBm	-35.7 dBm	5.3 dB
3	-29.8 dBm	-33.4 dBm	3.6 dB
4	-32 dBm	-33.5 dBm	1.5 dB
5	-32 dBm	-33.6 dBm	1.6 dB

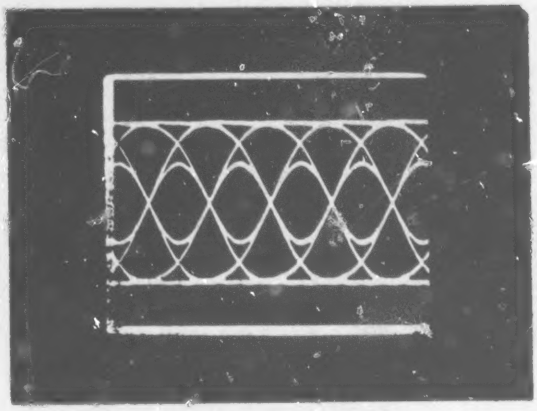
System Margin for 10^{-9} BER = Received Power − Minimum Received Power

The minimum system margin objective was 6dB at a bit error rate of $(10)^{-9}$. The concensus of opinion among the engineers were that this was a routine problem that could be solved by the following solutions: 1) equalization, 2) improved receiver sensitivity and bandwidth, and 3) increased laser output.

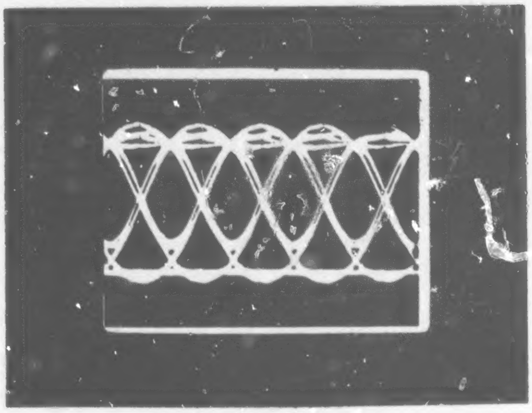
A lot of effort was expanded in developing an equalizer. Standard RC/LC equalization methods will not contribute to system margin as the noise will increase almost as rapidly as the signal. Good results were obtained by utilizing transversal equalization as shown by the eye patterns in Figure 1.



Transmission BW = 60MHz
No Equalization
Fig. 1A



Transmission BW = 30MHz
No Equalization
Fig. 1B



Transmission BW = 30MHz
with Transversal Equalization
Fig. 1C

Fig. 1A is a pattern of a 90Mb signal through a transmission system with a bandwidth of 60MHz. The pattern is fairly good, but it deteriorates quite severely when the bandwidth is reduced to 30MHz as shown in Fig. 1B. The effectiveness of the transversal equalizer is shown in Fig. 1C.

Unfortunately, we did not have the opportunity to test this equalizer in the system as the engineer assigned to the equalizer project did not complete the design and was no longer with the company when we started the field tests. The receiver bandwidth was increased and a small amount of RC equalization was inserted.

When the modified receivers were field tested, the results did not make much sense because of a large variation in the system margins. The increase in margin that was anticipated did not occur. Many combinations of receivers and transmitters were tried on a single fiber and the same combinations were tried on different fibers. Some of the data resulting from these tests are shown in Table II.

Table II
East to West

Fiber No.	Xmitter No.	Xmitter Power dBm	Rec'r No.	Rec'd Power dBm	System Margin dB
5	45	-.2	1	-29.2	0
5	45	-.2	4	-29.2	4.2
5	45	-.2	45	-29.2	5.9
6	45	-.2	1	-29.2	0
6	45	-.2	4	-29.2	6.8
6	45	-.2	45	-29.2	8.6
6	12	+.3	1	-26.7	0
6	12	+.3	4	-26.7	6.7
6	12	+.3	45	-26.7	8.2

In the opposite direction (West to East).

Fiber No.	Xmitter No.	Xmitter Power dBm	Rec'r No.	Rec'd Power dBm	System Margin dB
6	35	-.4	10	-29.9	4.7
6	35	-.1	12	-29.9	0
6	35	-.1	13	-29.9	5.4
6	4	+.8	12	-28.8	0
6	4	+.8	45	-28.8	6.2
6	4	+.9	45	-28.8	5.5

The received power was fairly consistent between the various transmitter/receiver combinations and fibers. The modified terminal equipment showed significant increase in system margin with some combinations and no improvement and even deterioration of system margin with other combinations.

Bandwidth penalty was suspected in the fibers with low system margin. Therefore, the laser power was increased to +3dBm and to +6dBm. The resulting measurements were inconsistent again. On some of the combinations, the margin increase was greater than the ratio of power increase and other combinations showed very little increase in the system margin. The results are shown in Table III and Table IV.

Table III
Increased Transmitter Power to +3dBm
East to West

Fiber No.	Xmitter No.	Xmitter Power dBm	Rec'r No.	Rec'd Power dBm	System Margin dB
5	10	+3.0	1	-25.7	8.7
5	10	+3.0	4	-25.7	7.0
5	10	+3.0	35	-25.7	9.1
5	12	+3.0	1	-25.5	2.8
5	12	+3.0	4	-25.5	2.8
5	12	+3.0	35	-25.5	5.5
5	13	+3.0	1	-25.6	8.2
5	13	+3.0	4	-25.6	8.0
5	13	+3.0	35	-25.6	8.0
5	45	+3.0	1	-26.5	5.8
5	45	+3.0	4	-26.5	5.8
5	45	+3.0	35	-26.5	8.5
6	12	+3.0	10	-24.1	5.1
6	12	+3.0	45	-24.1	12.2
6	13	+3.0	10	-25.3	7.3
6	13	+3.0	45	-25.3	11.4

Table IV
Increased Transmitter Power to +6dBm
East to West

Fiber No.	Xmitter No.	Xmitter Power dBm	Rec'r No.	Rec'd Power dBm	System Margin dB
6	45	+6.0	12	-23.3	4.1
6	45	+6.0	4	-23.3	10.9
6	45	+6.0	1	-23.3	14.7
5	45	+6.0	1	-23.5	8
5	45	+6.0	35	-23.5	10.3
5	45	+6.0	13	-23.5	0

It was evident that more information was required to understand what was happening in the system. The bandwidth of the fibers were measured and the results are listed in Table V.

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Table V
Fiber Bandwidth Measurement
East to West

Fiber No.	3dB Electrical BW	6dB Electrical 3dB Optical
1	29 MHz	46 MHz
2	33 MHz	51 MHz
3	32 MHz	53 MHz
4	33 MHz	48 MHz
5	30 MHz	49 MHz
6	35 MHz	59 MHz

The fiber bandwidths were narrower than we had assumed. However, even with this additional information, the reason for the poor margin with certain combinations of equipment and fiber could not be explained.

Many photographs of the eye patterns were taken, but the eye patterns did not disclose any significant differences between the combinations that produced a large system margin versus the combination that produced a poor system margin. The eye patterns were studied for noise and only slight indications of noise were found. Four of these photographs are shown in Figure 2.

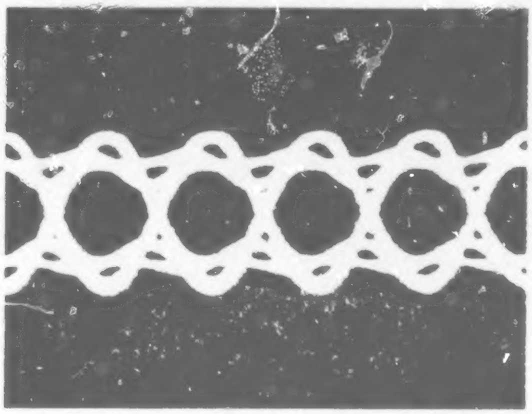

Fig. 2A
Ideal Condition
Amplifier Looped on Itself

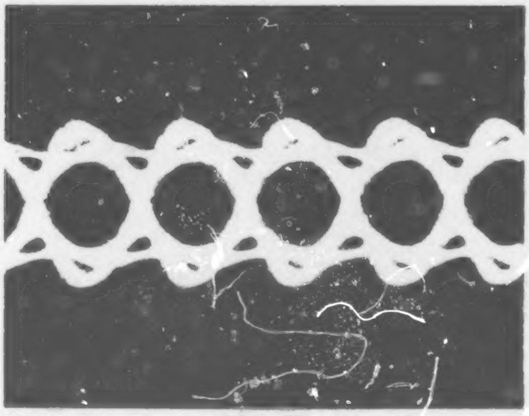

Fig. 2B
System Margin 8.2dB

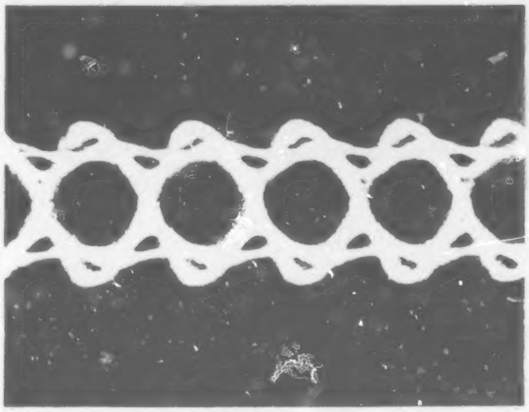

Fig. 2C
System Margin 2.8dB

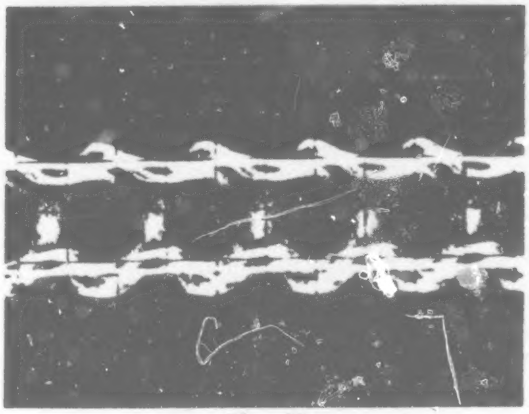

Fig. 2C
Worst Condition System Margin OdB

The data was placed into matrix format in hopes that better correlation of the data would be obtained.

The various combinations of transmitters and receivers gave evidence of the presence of modal noise. This type of noise is directly related to the light source coherency in the transmitter along with the splice joints and the fiber coupling connectors where mode-selective losses occur. The resultant noise manifest itself in the form of amplitude modulation of the optical signal. The phenomena of modal noise is a multipath problem which is fundamental to multimode fiber optics systems with mode selective losses.

CONCLUSION

After many hours of discussions and data sifting, the following conclusions were reached:

1. The fiber bandwidth was too narrow to transmit 90 mb over 35Km to maintain a BER of 10^{-9}.

2. Modal noise was a major problem; therefore, increasing the power did not help the fibers sensitive to modal noise.

3. As modal noise is also dependent upon the spectral width of the laser, the different combinations of equipment affected the system margin on the fibers liable to produce modal noise.

4. If modal noise was caused by bad splices, it was not practical to search out these splices over 35Km of cable.

No attempt was made to measure the spectral width of the lasers because test equipment was not available and time was becoming a critical factor.

The terminal manufacturer was concerned that it would be extremely difficult for them to support this system if they had to supply Hawaiian Telephone Company with specially selected lasers. Although the lasers were supplied by NEC and Lasertron, the amount of lasers that could be delivered was very limited.

There was agreement among the engineers that although a repeaterless, multimode system at a 90Mb/s rate was theoretically possible, it was not practical for a long term commercial system at 35Km. The final configuration that was installed was a standard production model 90Mb/s, long-wavelength, multimode system with a repeater installed at the Aiea C.O. which is 21Km away from Wahiawa and 14Km from Honolulu. The system installation was not completed at the time this article was written so the final system margin is not known.

ACKNOWLEDGEMENTS

The author would like to thank L. W. Ulbicht of GTE Laboratories, who was the principal engineer on this project and his assistant, Pete Baum, Bert Basch of GTE Laboratories for his input in analyzing the problem and Dean Crawforth, of GTE Communications Systems, and his staff in providing the equipment and technical assistance.

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DIGITAL UNDERSEA CABLES: PROGRESS AND APPLICATIONS

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ABSTRACT

International and Intercontinental Telecommunications have relied upon undersea coaxial cables as one of the prime media of transmission over a period of about 30 years. Some distinct advantages flow from the introduction of digital optical technology into undersea cable systems. Costs have already been demonstrated to have dramatically reduced, and technology is advancing so rapidly that these processes will inevitably continue. Many of the operational advantages enjoyed exclusively in the past by satellite communications will become realisable with the flexibility offered by digital undersea cables.

1. INTRODUCTION

The world network of undersea telecommunications cables is a major contributor to the well-being of business and social intercourse between nations. In the Pacific, North-South and East-West axial highways have long existed, and continue to be expanded. At 1984 year-end the status of the world cable network was as follows:

Number of installed systems	224
Total route nautical mileage	179,000
Total Provisioned voice-grade circuits	187,000

To date, the network has been based upon conventional coaxial cable technology. Testimony is borne to its effectiveness in that almost $4.5 billion has been invested in building up the network as presently perceived. The present decade already has witnessed moves towards the employment of digital techniques on an increasing scale. From urban applications initially, through domestic longline networks more recently, the advance of digital technology into the international arena has commenced. Undersea cable technology has moved with the times. Contracts have been placed for a high capacity digital highway across the North Atlantic (TAT-8), due for completion in 1988. Wide-ranging plans are under evaluation for similar links in the Pacific, Caribbean, and Mediterranean Basins.

2. DIGITAL UNDERSEA CABLES

Early evaluations of the application of digital techniques to undersea cables demonstrated that established coaxial technology, while feasible, would not be cost-effective in an environment of two countervailing pressures; inflation on the one hand, and reducing service tariffs on the other. (1) Application of optical fibres as the transmission medium was recognised as the solution for these economic limitations. It was also quickly recognized that, in the drive towards maximum cost effectiveness, the use of multimode fibre was unlikely to achieve a significant cost breakthrough relative to wideband coaxial technology. Accordingly, the conscious decision was universally taken that, for undersea cable communications, single mode fibre would be exclusively employed. Cost criteria were evaluated and targets set. Two major objectives evolved, namely;

(i) Capacity per fibre pair equivalent to that provided by the largest available coaxial systems, with per-circuit costs reduced by at least 25%.

(ii) Transatlantic capability providing at least twice the circuit capacity for an investment in real terms, no greater than that for the largest available coaxial cable.

Engineering development aimed at harnessing state-of-art optical technology to defined economic criteria led to a set of general parameters for a "first generation" of undersea optical cable systems (Fig 1).

Achievement of cost targets by systems based on the stated parameters have been amply demonstrated by planning experience on TAT-8. Per-circuit investment, compared with its immediate predecessor (TAT-7, coaxial, 4200 circuits) is of the order of 25% less for approximately double the capacity, implemented five years later in time. The significant scale of cost benefit has been realised essentially in two ways:

(i) Low transmission loss of single mode fibre has permitted cost savings in submerged electronic hardware, since much greater repeater spans are achievable than would be possible in coaxial systems of comparable capacity.

(ii) The capability to accommodate multiple fibre pairs within a single cable structure has permitted large circuit capacity increases to be realised at low incremental cost.

Notwithstanding, technology progress is providing pointers to the directions which future optical undersea systems are likely to follow. From a first generation, operating at 1.3 microns, the next step could be exploitation of longer wavelengths rather than enhanced bit-rate, for this is seen to provide more positive cost benefits. Laboratory evaluation of single mode fibre performance in the third window (1.55 micron) has demonstrated that a doubling of repeater span, as a minimum, is feasible. Concurrent research into active devices aimed towards increased performance, integrity, and reliability will, when translated into large scale production capability, add further positives into the undersea optical cable economic equation. The concept of a "second generation" of systems is thus risen over the horizon. Their final physical form has yet to be determined, although several of the key features are recognised (Fig 2). These alone serve to further cost-effectiveness, and although other techniques of digital enhancement are available from a wide portfolio, their effective application may be specious. The key element is without doubt wavelength, for system reliability, as ever, hinges upon component technology rather than the transmission medium itself. The tradeoff between resource optimisation of the transmission medium and minimisation in the numbers of submerged devices of every kind defines a goal, in terms of reliability, that coaxial technology would have found increasingly difficult to achieve, had it moved forward into another generation. The converse is true for optical technology, thanks to the freedom of movement that wavelength exploitation bestows.

3. EXPERIENCE TO DATE

In common with all excursions into new areas, experience of undersea optical technology is presently limited, for all will remain empirical until systems enter active service. It is not to say, however, that no progress is being made along the learning curve. Sufficient data has been amassed in areas such as the mechanical properties and performance of fibre (on its own and cabled); component technology, etc, to enable risk areas to be identified and appropriate care to be taken. (1,2) The main address is that of reliability, for it is in this area that undersea cables have established their reputation. The in-service reliability offered by the new digital/optical technology must at least be as good as, if not better than that which prevails in the coaxial environment. Typical target expectancy for the most vulnerable components is 1×10^{-4} failures in 25 years in a system of 6000 km length. Reliability expectancy of other components is better by at least an order of magnitude. Reliability safeguards may be readily designed into undersea optical cables by means of redundant sub-systems. There are several approaches:

(i) Combinations of laser, and switched fibre redundancy,

(ii) Switched fibre redundancy alone,

(iii) Laser redundancy alone.

While the first of these may be viewed as the ultimate in contingency planning, there are threads of evidence emerging as experience is gained that it tends towards "overkill", and is costly too. It also begs a conscious decision, as does the second approach, as to the way in which fibre switching can be best effected. In the coaxial domain, mechanical switching in an undersea environment has remained abhorrent to the professional system designer.

If fibre switching is considered necessary, maintenance of reliability rests with an appropriate design of a device without moving parts. The principle of the microwave directional coupler is apposite in this respect. The task is to adapt the principle to an optical environment.

The third approach, laser redundancy, has become generally accepted in principle. For systems of the "first generation", laser redundancy is considered essential in a transoceanic context. Nevertheless, experience gained under simulated conditions confirms we are over the first hurdles in regard to laser wearout. More work needs yet to be done, and is being done. As the work proceeds more optimism results; so holding the promise that in the "second generation" of systems, even laser redundancy might be dispensed with.

4. NETWORKING

Turning to service applications and reliability, undersea optical cable systems offer a potential which coaxial cables cannot; that of "networking". One could conceive of an ideal situation, whereby using strategic terrestrial nodes, and submerged branching units, a complete ocean area could be covered by a single integrated network in which direct access to any one point may be gained from any other. In a theoretical sense, the idea simply emulates what satellite communications already do, but is it really practical?

Networked configurations embrace three groupings: pairs, broadcast, and rings, (Fig 3). Pair configurations could employ some form of simple submerged branching, permitting direct pairs between all destinations, or indirect pairs interfaced at a node to be provided. Direct pairs afford maximum operational security and acceptability; though indirect pairs, given co-operation between partners offer no less a facility.

Broadcast and ring configurations, of necessity, must in some way be branched under water. Both methods impose restrictions upon the capacity available for specific point to point relations, and imply some form of packet switching or other

TDMA mode of operation. Also to maximise effectiveness of these configurations begs active branching units which would introduce a further factor into an overall reliability equation. Operationally, neither offer security of communications in the sense that traffic not intended for one specific terminal is nonetheless capable of interception, should a collapse of political goodwill occur.

5. COSTS AND OTHER BENEFITS

A previous mention was made of the cost benefits achievable by the introduction of optical technology into undersea cables. Historically, each capacity increment achieved in coaxial technology has resulted in per-circuit cost benefits in real terms (Fig 4). Present indications suggest approaching the law of diminishing returns situation with evidence of bottoming-out in the cost characteristic. Redress is demonstrated in the transition from coaxial to optical technology, with TAT-8 costs providing the leading indicator. From this start, cost reduction will be ongoing, particularly as longer wavelength optical transmission becomes practicable. Nevertheless there are features of the new technology which could create pitfalls in the economic sense. Cost optimisation and route configuration are interdependent, so what might appear an elegant technical solution may not be the best economically. Moreover, a certain configuration may be made more complex than another in the quest for a networked solution. Complexity added could be in inverse proportion to reliability expectancy. To achieve complexity and target reliability could involve disproportionate cost. Thus any sought after cost benefit could be quickly eroded.

When considering which might be a "best"solution economically out of a number of possibilities, route geometry becomes a significant issue. For a given unit cost per kilometre for a single fibre pair; and a geometric configuration based upon two rightangled triangles; a simple sum shows the cost involved in linking three nodes A B and C in a discrete fashion (Fig 5). Also, given that the addition of a second fibre pair could increase the cost per kilometre by 20%, corresponding costs may be determined for branched and internode configurations to achieve the same traffic relation objectives. Clearly, the least cost solution is not that embodying the most sophistication. It is however the one which needs the most goodwill among partners. Fortunately for all in the business of international telecommunications, a great deal of goodwill build up and cemented over years of operation lastingly remains.

Surprisingly, the simple cost analysis described even bears upon TAT-8. Setting aside issues of operating expediency TAT-8, with its long "spine" and two short "tails" joined at a branching unit provides a cost solution marginally greater than could have been achieved by employing two discrete links interfaced at a European terrestrial node.

Configurations aprat, there are other areas in which undersea optical cables demonstrate positive benefits. One is technological compatibility between different system designs. This has come about as a result of detailed deliberations during the process of facility planning for the North Atlantic and Pacific. In matters of fundamental principle, though not necessarily in minutiae of detail, progress towards total transparency between otherwise unlike systems is being realised. This means that networks are capable of being developed to a set of common parameters, thereby obviating the problems of crossing boundaries from one hierarchy, or line code, etc to another. The freedom of choice offered by CCITT recommendation G.371 as to the way in which FDM signals are conveyed over a coaxial undersea cable ought nevertheless to be maintained in similar spirit for digital, optical cables in order that their fullest potential may be realised.

There is also merit in exploiting the higher order of bit-rates rather than the lower. (3) Bearing in mind that most inland long distance networks are predicated upon units of 90 or 140 Mb/s as a basic "building block", then it is these same units which determine the interface with the international network. A transmission speed of 280 Mb/s has been decided upon as the basic "highway" element for three reasons:

(i) Convenience of interface with backhaul inland facilities,

(ii) Cost-effectiveness compared with coaxial alternatives,

(iii) The world is not yet ready for anything larger.

Although many of the world's traffic streams would not on their own merit the use of 280 Mb/s exclusively, satisfaction of need through proliferation of systems designed around lower bit rates may not provide a satisfactory cost solution. Unlike coaxial cables, where the capacity/cost characteristic tends to a cube-root relationship, increase or reduction of bit-rate in optical cables results in cost incremental steps of only a few percentage points. Because the world cable network as currently structured falls into two distinct volume segments:

- Requiring arteries of 3000 circuits or more (the North Atlantic and Mediterranean)

- Requiring arteries of 2000 circuits or less (the rest) there might arguably be a case for two levels of optical systems; 280 Mb/s and, say, 140 Mb/s. However, there is an established precedent, now, whereby economies of scale provided by medium and large capacity cables are exploited through multi-country co-ownership, each country being assured access to the cablehead for their traffic. In the prevailing situation where cost differentials of the order of 50-60% are involved between one system capacity and another, co-ownership approach is apposite. It could be equally apposite in more fully exploiting the economy of scale offered by high bit-rate optical systems when cost differentials of the order of only 10% occur between systems of 280 and 140 Mb/s. It could thus be argued, particularly in a long-haul context, that 280 Mb/s suits most applications, and that changes of less than two octaves may not be sensible. The CEPT precedent (2, 8, 34, 140 Mb/s) for landline systems transcribes into a theoretical 70, 280, 1000 Mb/s in undersea applications. While a theoretical 1 Gb/s has been postulated as being too large, too soon; equally for anything less than 70 Mb/s coaxial technology could still offer economic advantages!

Thanks to the transition into a new technology, undersea cables can move back into operational areas hitherto dominated by satellites. Digital transmission will offer transparency such that all classes of traffic can be handled with equal facility. Constraints on services such as TV and certain categories of wideband data transmission will be removed, so placing optical cables on a more equal footing with satellites. In terms of costs, it can be demonstrated that high capacity coaxial cables can match satellites over distances up to 10000 km when the present worth of the space segment lease rate is equated to the first cost of a cable circuit over a common 25 year term. Introduction of optical undersea cables,typically having two pairs of fibres each operating at 280 Mb/s will double the effective distance at a stroke! (Fig 6). The economic/technical mix offered by first generation optical undersea cable systems is apparently most favourable, and indicative of the directions in which the technology will move. It is interesting to consider optical systems now and in the future, and how effective they will be in competing against their natural rival, satellites. Not only is the potential offered for spanning greater distances than hitherto, given the same set of cable/satellite economic criteria, but also the enormous capacities which in future will be achievable must directly bear upon optical cable system economics. Historically cable and satellite costs have moved downward in ratios inverse to their available circuit capacities (Fig 7). The prospects for the INTELSAT VI programme infer that even with enhanced use of bandwidth attainable through TDMA/DSI little change in the cost/capacity characteristic is likely to occur. (4) By contrast, a significant step occurs in the cable characteristic as a consequence of the transition from coaxial to optical technology. Moreover the downward trend will be sustained, first by the use of longer wavelengths, and later by higher capacities if needed. A two octave increase from 280 Mb/s to the order of 1Gb/s at the longer wavelength could mean costs less than half those of TAT-8 for capacity comparable with that planned to be provided by each INTELSAT VI satellite.

Viewed in this light, optical undersea cables appear set to present a very strong challenge to satellites. With the ongoing cost benefits that can be demonstrated they may well assume a much larger proportion of the total provisioned capacity worldwide, particularly for intercontinental applications. In TAT-8, TPC-3, TAT-9, and PTAT 1 and 2, there are early signs of a trend which could accelerate, so long as no artificial competitive incentives are introduced into satellite economics.

Moreover, there are external forces in play which could further bear favourably on the greater use of optical undersea cables. These stem from deregulatory processes gaining momentum in the US and elsewhere. In Washington, the NTIA is mooting the use of international facilities more in line with market economy. Steps such as this bode well for undersea optical cables. But, to realise their full effectiveness, they need to be planned and structured in sensible fashion, with full account taken of the considerations presented here.

6. CONCLUDING COMMENTARY

Undersea optical cables will continue the tradition built over a qua[illegible] of a century by their coaxial predecessors [illegible]d will maintain - even enhance the role of [illegible]es as an essential element of world telecommunications. There are still problems to be overcome, reliability being paramount. As experience is gained, the solutions reached will form firm roots for progress. Cost effectiveness through technology change has been demonstrated, and will be further developed as time goes on. The new technology offers opportunity for new ideas in network planning and engineering. In this there could be a caveat; namely that the drive for technology promotion ought not to transcend reasonableness in the approach to planning. The traditional way of having direct cable links, planned and interfaced in an orderly fashion still appears to offer cost benefits. Without doubt, undersea optical cables will be more economic than satellite communications on more routes than achieved to date, due to lower costs per bit and the provision of a transparent digital medium. Moreover, with the much enlarged capacities available, diversity options could be wholly encompassed within the cable network.

FIG. 1

FIRST GENERATION SUBMARINE OPTICAL SYSTEMS

SYSTEM PARAMETERS	DESIGN DATA
Number of fibre pairs	2 or 3
Operating wavelength	1.3 micron
Bit-rate	280 Mbit/s
Number of Circuits per pair	4,000 approx.
DCME* multiplication factor	x 5
Total effective cable capacity	40,000 - 60,000 circuits
Cable diameter (for deep water)	25 mm approx.
Repeater spacing	30 to 60 km

* Digital Circuit Multiplication Equipment

FIG. 2

FACTORS INFLUENCING LATER GENERATION OPTICAL SYSTEMS

TECHNOLOGICAL INNOVATION	FORECAST SYSTEM ENHANCEMENT
Longer wavelength (1.55) Improved laser power Improved detector sensitivity	Increased repeater span
Higher bit rates	Increased capacity per fibre pair

FIG. 3 BRANCHED OPTICAL CONFIGURATIONS

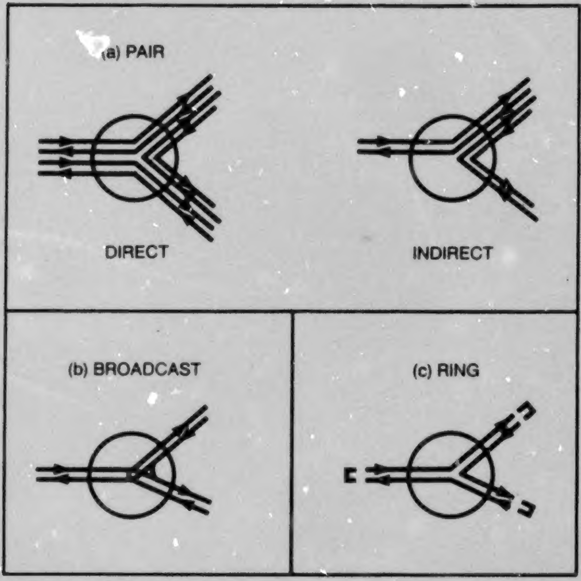


FIG. 4 RELATIVE PER-CIRCUIT COSTS FOR TRANSOCEANIC CABLES

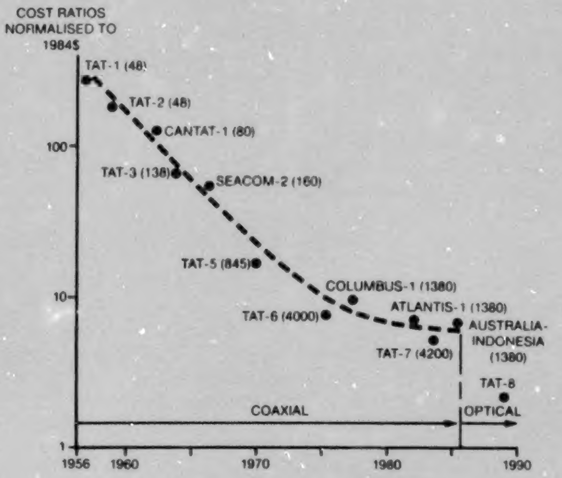


FIG. 5 OPTICAL "NETWORKING"; EMPIRICAL COST VS CONFIGURATION

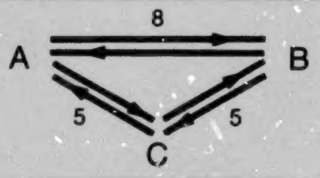
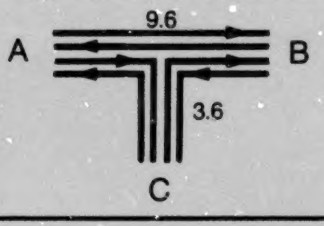
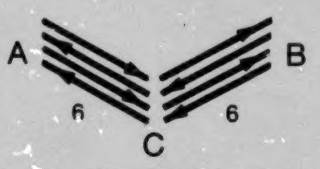
NETWORK CONFIGURATION	TOTAL COST
	18.0
	13.2
	12.0

FIG.6 COMPARATIVE CABLE/SATELLITE PER-CIRCUIT COSTS (CONSTANT 84 $)

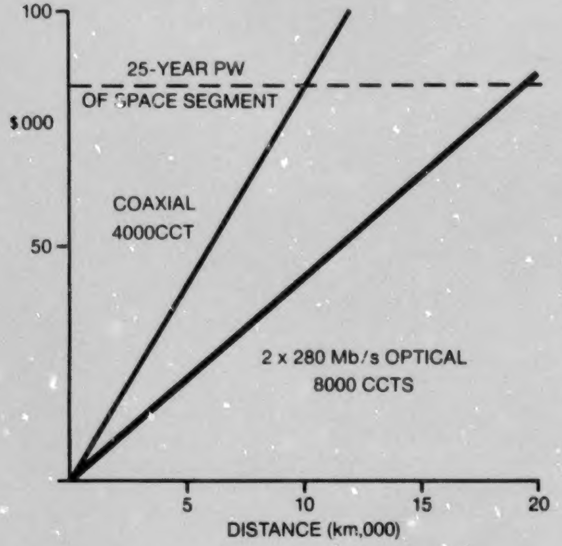
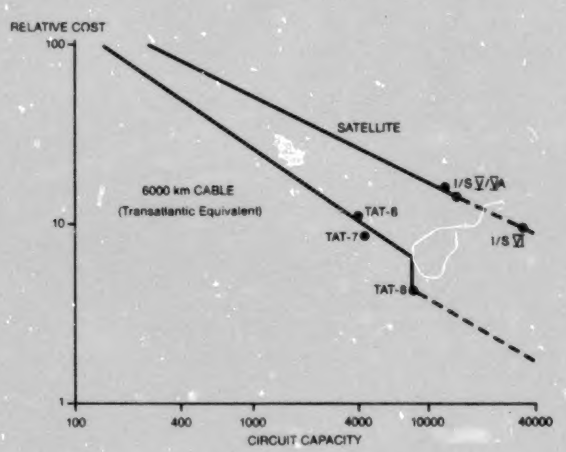


FIG 7 COMPARATIVE PER-CIRCUIT COSTS; IMPACT OF TECHNOLOGICAL PROGRESS



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BROADCAST COMMUNICATIONS IN AUSTRALIA

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1. Abstract

Broadcast communications in Australia and some of Australia's relationships with neighbouring countries are described. The influence of Australia's geography and population demographics on its broadcast communications and the services that have been implemented is discussed. Information on the broadcast communications industry, its Institutions, its regulation and its financing is reported together with details of existing services and services planned for introduction. Forecasts are made on the future of Australia of services such as DBS, MDS, CABLE and Pay Television.

2. INTRODUCTION

The purpose of this contribution to the PTC '85 Seventh Annual Conference is to review the existing state of broadcast communications in Australia, and to discuss future possibilities.

Broadcast communications is that part of a country's telecommunications activities, which enables electronically generated aural and visual experiences to be obtained instantaneously within one's home. The existing services that enable Australians to enjoy such instant sound and vision reproduction in their homes, or those services of future interest are :

Existing Services

- Radio Australia in the HF Band.
- Sound Broadcasting in the AM Band.
- Sound Broadcasting in the FM Band.
- Television Broadcasting in the VHF/UHF Bands.
- Wired Systems : MATV and CATV.

Planned Services

- Homestead and Community Broadcast Satellite Service, due to commence late 1985.

Services under Review

- Wired Services, including CABLE.
- Direct Broadcast Satellite (DBS).
- Microwave Distribution Service (MDS).
- Pay Television, particularly Radiated Subscription Television (STV).

3. GEOGRAPHY AND POPULATION DEMOGRAPHICS

The domestic sound and television services in Australia are in many ways different to those of other countries and regional areas around the Pacific basin. There is a multiplicity of reasons for this, including a country's particular history, geography, varying political and economic circumstances. The Australian situation will be reviewed, to provide a background and information to serve as a basis for comparison by others.

Australia is the largest island continent in the world. Its closest neighbours are New Zealand, Papua New Guinea, Oceania and Indonesia. These five relatively large areas are very diverse. Indonesia is a densely populated island archipelago adjacent to mainland Asia. It is thought of as a developing country, but was one of the first to adopt satellite technology to solve domestic telecommunications problems. Papua New Guinea is a rugged tropical country with underdeveloped industry and limited economic resources. Negotiations have resulted in Papua New Guinea being offered transponder capacity in Australia's first domestic satellite, which is planned to become operational in the second half of 1985. Oceania consists of a large number of relatively small and widely separated islands. Because of their geographic, political and economic circumstances, the introduction of modern telecommunications has been slow. Australia and New Zealand have now become deeply involved in the development of telecommunications for Oceania, by supporting projects under the auspices of the South Pacific Bureau for Economic Co-operation. The development of telecommunications in New Zealand and Australia is comparable, and close co-operation exists between them on all communication matters of common interest.

Australia is a well-developed industrial country in the fashion of other western democracies. It is distant from its main markets in Asia, Europe and the Americas. By any measure, Australia has a small population, measured in terms of its geographical size. This is illustrated below, which shows the area and population listed in the 1984 World Almanac of a number of countries in the Pacific Region.

Country	Area M Sq. Km	Population M
Australia	7.7	14.8
Japan	0.38	114.8
Malaysia	0.33	14.7
Indonesia	1.90	151.0
Mexico	1.95	71.3
United States	9.4	222.9

Australia's small population is very heavily urbanised. These urban areas are mostly located within the coastal areas along the south-eastern, north-eastern and south-western seaboards. The population of Sydney is about 3.4 million, Melbourne about 3 million and Brisbane, Adelaide and Perth are each approaching one million. These five State Capital cities account for about 60% of Australia's total population. A further 3 million i.e. 20% of Australians live in the towns or on the farms within these coastal areas, which is about 12% of the total land mass of Australia. Because of the great distances involved even within these coastal regions, the majority of these 3 million provincial Australians are distant, at least in terms of telecommunications, from the five Capital cities. Away from these coastal regions, there is a relatively thinly spread rural population who cultivate the remaining arable land within Australia, which mostly lies inland for a few hundred miles from the coastal areas referred to above. The rural population represents about 15% of the total population of Australia and occupies an area estimated to be 18% of the Australia land mass. That leaves 5% at most of Australians occupying the remaining 70% of Australia. These are the people of the Outback.

A fortunate consequence of Australia's urbanisation is that it has enabled viable and modern telecommunications to be readily supplied in the densely populated coastal areas. In the less populated areas of Australia the provision of telecommunications has often been slow. In some remote locations the level of telecommunications has been unacceptable, if it exists at all. This lack of satisfactory telecommunications is directly attributed to the twin constraints of long distances and difficult terrain, measured in physical and economic terms. In an endeavour to meet the widely supported political concept of universal service, Australia has supplied telecommunications in the less populated areas by 'cross-subsidy' from the well-developed and viable services in the urbanised parts of the country. For this and other reasons, telecommunications services in Australia except for broadcast communications have been invariably supplied on a monopoly basis by Government owned Instrumentalities.

4. INFRA-STRUCTURE AND REGULATION

Almost from the commencement of sound broadcasting in the 1920's, Australia opted for a dual system. This concept involves two radically different and competitive streams of broadcasting. One is a Government-funded, nationally orientated service intended for all Australians no matter where they live within Australia. The other is for commercially orientated regional services funded by paid advertisements. When television broadcasting was authorised to commence in 1956, Australia again opted for the dual system of broadcasting. Indeed this dual system concept has been a dominant feature of broadcast communications development in Australia for half a Century.

In the last decade however, a third tier, that is public broadcasting has been authorised. Public broadcasters are required to be funded mainly by public subscription, and to a minor extent by commercial sponsorship and government subsidy. At this time 38 public sound broadcasting stations have been authorised. So far all advocacy for a publicly funded television broadcasting service has been unsuccessful.

In Australia, broadcast communications has always been seen to be of tremendous social and political significance. Mr. A. Staley, in a Ministerial Statement of 5 April 1978, made the point in his summary

"In short, broadcasting is so powerful a social and communications instrument, so valuable a national resource, so crucial to the public interest, that no government can afford to ignore it."

In view of this perception, the Australian Government, or its nominees, has always closely monitored all aspects of broadcast communications covering existing practices, establishment of new services and technological developments. It has been the subject of wide-ranging debates in Parliament, extensive coverage in the Press and numerous Inquiries. It is not surprising then to find that the broadcast communications industry in Australia is heavily regulated in most aspects including ownership, control, programme standards, technical performance etc.

An outline of the formal infra-structure that now exists for the oversight and regulation of broadcast communications follows. The people in Australia, by democratic process at intervals of about three years, elect a Government. The Government appoints a Minister of Communications, whose responsibilities include the protection of the public interest in broadcast communications for the people of Australia. The Minister has a Department of Communications, which is intended to assist the Minister over the whole range of responsibilities. This includes all matters relating to the provision of postal, telegraphic, telephonic and broadcasting covered by legislation for which the Minister is responsible.

The Department of Communications has six functional Divisions namely : Broadcasting Policy and Planning, Broadcasting Services, Communication Development, Corporate Policy and Projects, Radio Frequency Management and Space, Telecommunications and Postal Policy. Those Divisions of the Department of Communications which are most involved with broadcast communications are :

(i) Broadcast Policy and Planning, which is required to formulate broadcast policy, to develop broadcasting legislation and to plan for future broadcast developments.

(ii) Broadcast Services, which is responsible for the specifications of individual broadcasting stations, and the establishment and operation of the Government-funded transmitters.

(iii) Communication Development, which is required to study and make recommendations on future developments over the entire range of communications.

Apart from the Department itself, seven Government owned or funded organisations fall within the Communications portfolio. They are Australian Telecommunications Commission (Telecom), Australian Postal Commission, Overseas Telecommunications Commission(Aust), Australian Broadcasting Tribunal, Special Broadcasting Service, Australian Broadcasting Corporation and Aussat Pty. Ltd. These major authorities have been established with varying degrees of autonomy or independence from Government control. As statutory bodies, they are required to report to and obtain approval for annual appropriations from Federal Parliament. The administrative mechanism for this is provided by the Department of Communications.

These statutory bodies are all involved in broadcast communications either directly or indirectly but three of them are of particular interest -

(i) Australian Broadcasting Corporation (ABC) (established in June 1983 following an Inquiry, previously was Australian Broadcasting Commission). It is the Government-funded broadcaster, charged with the responsibility to provide national sound and television broadcasting programme services.

(ii) Special Broadcasting Service (SBS) is a second Government-funded broadcaster, established in 1979 to provide sound and television services of a special nature, mainly to meet the needs of recent immigrants to Australia.

(iii) Australian Broadcasting Tribunal (ABT) whose general responsibility is to supervise all commercial and public sound and television broadcasters activities, and in particular the licensing of stations, setting programme and advertising standards and monitoring station adherence to these standards and ensuring that ownership and control provisions are met.

5. EXISTING AND PLANNED SERVICES

5.1 Existing Services

5.1.1 Radio Australia has high-powered high frequency (HF) radio transmitters located at Lyndhurst, Shepparton, Carnarvon and near Darwin to provide sound broadcasting services to overseas listeners around the world. It is responsible for the production of two twenty-four hour per day programme services. One is totally in English. The other one provides nine hours in Indonesian, two in Cantonese, three in Standard Chinese, two in Japanese, one hour each in Thai and Vietnamese, and three hours a day to Papua New Guinea and the Pacific in English and Melanesian.

Also, the ABC currently operates HF services intended for coverage of Australia's large and sparsely populated Outback.

5.1.2 Sound Broadcasting in the AM Band

Amplitude Modulation (AM) sound broadcasting in Australia generally conforms with established international technical operating standards. Australia co-operates with its near neighbours in specifying operating frequencies and output power levels. All sectors of the Australian broadcasting industry provide AM sound broadcasting services. The ABC has two national networks and 95 transmitters. There are 130 stations owned and operated by commercial broadcasters, 5 by the public sector and 4 by SBS. Authorisation has been given for AM sound broadcasting in stereo to commence from February 1985. The transmission standard specified is the Motorola System. Australia has licensed two AM stations for the print handicapped.

5.1.3 Sound Broadcasting in the FM Band

Frequency Modulation (FM) sound broadcasting in Australia generally conforms with established international technical operating standards. During the early days of television broadcasting in the 1960's, the decision was taken to utilise the international FM band of 88 - 108MHz for television, in the belief that FM sound broadcasting was not to be introduced in that Band. When this position was reversed in the early 1970's, it meant that there was a limited availability of channels for FM sound broadcasting at least until the Band is cleared of television. The Government intention is to clear the FM Band of television but this is likely to take several years. Nevertheless FM sound broadcasting commenced in the middle 1970's. There are now 72 FM sound broadcasting stations operational around Australia, shared between the ABC, public and commercial sectors.

The availability of sound broadcasting stations around Australia is inequitable. For example there are 10 AM and 8 FM stations in Sydney, 6 AM and 5 FM stations in Adelaide, in a typical regional area such as Orange there are 2 AM and 1 FM station, and in the Outback there are only the HF services. In the past, Government policy recognised that commercial broadcasting services in most regional areas would only survive as a monopoly, and would not be viable in sparsely populated areas. Such policy produced the existing inequality of services. Government priorities now prefer the principle of universal service of broadcasting communications for all Australia. As one step, the Government has approved the supplementary licence scheme in order to increase the diversity of commercial broadcasting in regional areas. This allows the owner of a normally licensed solus station in a regional area, to operate a second or 'supplementary' station for a period of at least 8 years.

5.1.4 Television Broadcasting in the VHF/UHF Bands

Although there are some differences, television broadcasting in Australia using the VHF/UHF Bands generally conforms with established international technical practices. Australia's television standard for terrestrial broadcasting is 625/50 B/PAL.

Television broadcasting in Australia commenced in late 1956, following earlier approval for one ABC and two commercial stations in each of Sydney and Melbourne. Since then, television broadcasting has expanded through a series of planned stages initially into the other mainland State Capital cities, then into regional areas and finally into small towns in the Outback. In these latter locations, only a Government-funded service that is the ABC, is usually available, for it is considered that a commercial service is not viable. Concurrently, additional services were licensed in the mainland capital cities. Along the way, colour television has been permitted since 1975. Its introduction has been an overwhelming success, an indication of which is that 91% of homes in Australia now have at least one colour television set.

The availability of television broadcast services around Australia is inequitable. In Sydney and Melbourne, there are five stations operated by the ABC, SBS and three commercials. In Regional areas there are usually two stations, one operated by the ABC and the other by a commercial broadcaster. In remote areas, there may be an ABC station or none at all. At present, it is estimated that the ABC can be received by 99% of the population, 90% can receive at least one commercial station but less than 70% are able to receive five channels. In order that the ABC might achieve a high level of penetration to meet its obligation as a national broadcaster, the Government within budgetary constraints has exploited every practical technology including the use of translators, repeaters and the remote area television scheme (RATS). RATS is a scheme which uses a Pacific Ocean Intelsat Transponder to relay the ABC national programme to earth stations at locations in the Outback. The received signal is then rebroadcast by means of a low-powered terrestrial transmitter.

The Government has also announced its intention to expand the SBS service. At the moment it transmits only in Sydney, Melbourne and Canberra, but it plans to commence transmissions in the other mainland capital cities and larger regional areas within two years.

In the case of commercial television broadcasting services, the Government has announced the introduction of a supplementary licence scheme for regional television broadcasters, in a manner similar to that described above for sound broadcasting stations in regional areas.

Broadcast videotex(teletext) has been permitted in Australia since 1982. Almost half the Australian television stations have started or are planning to start a teletext service. But most stations already transmit a few hours per week of teletext sub-titling for the hard of hearing. This activity has active support from the Government, through the establishment of a Caption Centre.

The most recent Government initiative has been to approve the transmission of two channel/stereophonic sound on television broadcasts in Australia, using the German two-carrier method.

5.1.5 Wired Systems : MATV and CATV

There is only a limited application of wideband wired or cabled systems for television distribution to be found within Australia. Master Antenna Television Systems (MATV) are small wired systems restricted to television distribution within the boundaries of a private property, and find application in hotels, motels and blocks of apartments. Community Antenna Television Systems (CATV) are wired systems which cross property boundaries, for which a licence must be obtained. The regulations require them to be of limited size (usually less than 100 homes), and to carry only locally radiated television broadcasts. There are less than 1,000 homes connected to CATV systems in Australia.

5.2 Planned Services : Homestead and Community Broadcast Satellite Service (HACBSS) is scheduled to commence in late 1985.

In 1977, an Inquiry was established by the Government to enquire into the future of domestic satellites for Australia. The terms of reference of relevance for broadcast communications were

"Investigate and evaluate the social, economic, technical, policy and other issues associated with the establishment and operation of an Australian national communications satellite system having particular regard to :

(a) the potential to provide high quality radio broadcasting, television broadcasting and other telecommunications services to all Australians ;
(f) the implications of a satellite system for the existing national broadcasting service, the public broadcasting service, the services of the Australian Telecommunications Commission and the Overseas Telecommunications Commission. This area of study should also involve implications of a satellite system for the present broadcasting and telecommunications terrestrial distribution systems."

In their Report, entitled 'National Communications Satellite System' issued July 1978, the recommendations of interest for broadcast communications were :

"(1) The introduction of an Australian national communications satellite system and that arrangements for its provision be commenced as early as practicable.

(7) That a Direct Broadcasting Service, directed towards the provision of the national television and radio services to isolated communities and homesteads beyond the range of coverage of terrestrial broadcasting services, be considered for inclusion in the national communications satellite system."

After a prolonged debate on the social, economic and policy issues impacted by the recommendations, the Government decided in 1979 that Australia should have a domestic satellite system. The responsibility for implementing this decision was given to Aussat Pty. Ltd, which is owned 75% by the Australian Government and 25% by Telecom. The first series of Aussat satellites are Hughes D-type, each with four transponders of 30 Watts and eleven of 12 Watts transmit power. The down-link frequencies are 12.25 - 12.75 GHz, with a transponder bandwidth of 45 MHz.

The satellite is designed to have a national footprint covering the continental area of Australia together with its nearby offshore islands. There are five smaller footprints, referred to as Spot Beams. Each of these Spot Beams illuminates approximately one quarter of Australia in areas referred to as the South-East, North East, Central and West zones. The fifth Spot Beam is available for coverage of Papua New Guinea, but can be switched to an Australian Spot Beam. The Aussat satellites have been designed for both telecommunication requirements using the 12 Watt transponders and broadcast communication purposes using the 30 Watt transponders. The Department of Communciations has estimated that acceptable direct satellite reception of television is practicable using a modest sized dish of 1.5 metres, provided that a 30 Watt transponder operating into a Spot Beam is used. The Government decided that the ABC should provide a truly national service using four 30 Watt transponders with one operating into each of the four Spot Beams. This provides for a total coverage of all Australia. It is designated as the Homestead and Community Broadcast Satellite Service (HACBSS). It is primarily intended to provide television service to the Outback and other unserved areas, and for the delivery of ABC sound broadcasting services. In addition HACBSS is to be used for the carriage of the ABC television service to its regional rebroadcast transmitters located within Spot Beam coverages. This multiple use of HACBSS necessitated the adoption of the B-MAC signal format for HACBSS satellite transmission.

In November of 1983, the Government directed the ABT to conduct a further Inquiry whose main terms of reference were :

". Likely arrangements for providing satellite program services (SPS), that is programs (including advertisements) distributed via the satellite system to commercial licensees for rebroadcast on their stations.

. What measures are required to promote provision of commercial services to remote areas."

Following its Report, entitled 'Satellite Program Services' issued July 1984, the Government decided that a second and commercially based service should be licensed specifically for the Outback.

In order to prevent overlap with the existing licensed commercial broadcasters, the Government decided that the Remote Commercial Television Service (RCTS) should utilise the same technology as HACBSS, except that the signal has to be encrypted. RCTS is required to use the B-MAC format, for which encryption is an integral part. The Government has then defined the area to be served by an RCTS to be those parts of a Spot Beam coverage which are not included in the Service Areas of existing terrestrial commercial television stations or their translators.

The Government called for expressions of interest in the proposed RCTS licensees. At the closing date of November 20 there has been at least five responses for each of the four proposed RCTS service areas. Because of the economic constraints and small population to be served, RCTS should be seen as a brave experiment in the utilisation of satellite technology to bring commercial services to the people in the Outback. This decision, when taken together with the proposal for supplementary licenses in regional areas does reduce the inequality of broadcast services available in regional and Outback areas. However it still falls short of the Government's existing objective to have equality of broadcast communications for all Australia.

Of course, the satellite will be used extensively in its telecommunication mode for the interchange of broadcast material and relaying of SPS to licensed stations for rebroadcast. Current Government policy is for SPS to operate in a national beam and to be encrypted. The purpose for this encryption is to prevent SPS being fortuitously received by any domestic receiver, and thereby constrain SPS for only interchange and relaying.

5.3 Services Under Review

5.3.1 Wired Services, including CABLE.

As described above, the utilisation of wideband wired systems in Australia has been quite limited. The introduction of wide area, multiple channel systems has been delayed while a Government policy for such systems is being developed. To assist the Government in its deliberations, the ABT was directed to hold an Inquiry whose primary terms of reference were :

" . (1) the social, economic, technical and related matters that need to be taken into account in introducing cable television into Australia ;

(2) the range and diversity of services (including sound broadcasting and 'Pay-TV' and other subscription services) of an entertainment, information, educational or other kind that could be provided by means of, or in association with, cable television."

The report of their investigations entitled 'Cable and Subscription Television Services for Australia' issued August 1982 made seventy-seven recommendations the main one of which is

". R.3 That Australia introduce cable television services (CTV) and radiated subscription television services (RSTV) as soon as practicable."

So far, the Government has not acted positively on these recommendations.

In respect of the future of wide area wideband wired systems in Australia, two particular possibilities have received most attention. Firstly CABLE (in capital letters) is a term that has evolved in the United States to describe private owned, co-axial cable television distribution networks having a tree and branch topography. Secondly, Telecom in Australia could upgrade its existing narrowband switched network for wideband working, and thus provide a Government-owned nationwide, optical fiber switched star connected network. As CABLE is a mature technology, its capabilities and economics are well-known. In the case of the Telecom possibility, the opportunity exists for the transmission of all known telecommunication services including full motion television. Television will then be possible on a one to one basis, which is the ultimate narrowcast or for mass distribution of an unlimited number of television programmes.

In Australia, a comparative study indicates that Telecom is now well placed to provide and compete with any privately supplied CABLE system. Indeed I believe that Australia is sure to choose the Telecom option for its future. However, it is unlikely that Telecom will commence their upgrade within the next 4 or 5 years. Within the existing capital constraints on Telecom, it will probably take 40 or 50 years for the upgrade to be completed.

5.3.2 Direct Broadcasting Satellite (DBS)

It is necessary to clarify the difference between HACBSS and DBS because both enable the home delivery of television by direct reception of satellite transmissions. In opting for a hybrid satellite carrying both telecommunication traffic and for broadcasting, an appropriate downlink operating frequency band had to be selected. To conform with international practices, the frequencies chosen were 12.25 - 12.75 GHz, which allows the band 12.5 - 12.75 GHz to be used for direct broadcasting subject to a maximum Effective Isotropic Radiated Power (EIRP) level of 53 dBW. EIRP levels of about 60 dBW are permitted in the DBS bands.

It is calculated that a HACBSS transponder of 30 Watts into a Spot Beam will generate a signal having an EIRP of 47 dBW. It is then estimated that an acceptable television reception in the Outback will be obtained using a 1.5m earth station based on a low margin of 2/3db for equipment tolerances and rain attenuation. Latest information in Australia indicates the cost of a 1.5m earth station will be about $A2500 installed. Even if the EIRP was raised to the maximum value of 53 dBW, the cost of an installed satellite earth station is not expected to be less than $A1,000. Therefore HACBSS terminals are likely to be installed mostly in areas which are not served by terrestrial means, which usually require an aerial system costing about $A200.

The concept of DBS requires it to conform with the international definition of a broadcast service 'intended for direct reception by the general public' and reception at a satisfactory level of quality and reliability. This necessitates a satellite earth terminal costing about the same as a VHF/UHF antenna, in order that DBS might be competitive with terrestrial services. It implies an earth terminal of about 50cm size which requires a satellite transmit EIRP of 60 dBW when realistic margins are allowed for equipment tolerances of 3db and rain attenuation up to 6db, and a mass production of domestic type units to achieve the right price.

Government policy is against the introduction of DBS into Australia at this time. There is concern about the potential for DBS to destroy the existing television broadcasting industry arrangements. It is claimed that the present infra-structure has been carefully nurtured to meet highly desirable objectives of diversity of services, localism, acceptable levels of ownership etc. Also, it seems that the cost of satellites for DBS would be an intolerable financial burden for the Australian broadcasting industry.

Unless there are unexpected technological developments or major policy changes HACBSS/RCTS will be the main way by which people located in the sparsely populated areas of Australia will be able to receive broadcasting services for the next 10 years.

5.3.3 Microwave Distribution Service

There is a technological option to use omnidirectional terrestrial microwave radiation for broadcast communication purposes. Typical frequencies are 1.5 to 2 GHz. It is referred to as microwave distribution service, or sometimes multipoint distribution service, or MDS. However there is a worldwide reluctance to allocate such microwave frequencies solely for sound or television distribution, for such frequencies are in heavy demand for other services. The future of MDS is problematical, but its use in Australia for broadcast communications is likely to be minimal.

5.3.4 Pay Television, particularly Radiated Subscription Television.

Pay Television is a term that means different things to different people. For the purposes of this paper, Pay Television is defined as a television service, which involves a direct payment from a customer to the supplier of the television product. Pay Television is potentially realisable with every broadcast communications technology. Examples are Radiated Subscription Television (STV) which involves the use of terrestrial VHF/UHF television broadcast transmitters, MDS as described above, Pay-Cable which has developed as an integral part of CABLE in the United States and proposals using satellite technology. Such Pay Television services around the world have achieved only limited success. Invariably Pay services have become little more than exhibitors of premium movies. Sometimes sports and cultural programmes are offered but their impact on the viability of Pay services is marginal.

In Australia there has been a great deal of thought given to the introduction of Radiated Subscription Television (STV). Indeed the Australian Broadcasting Tribunal was asked to consider this matter at the time of its Inquiry into Cable referred to above. The ABT recommended the introduction of STV into Australia, but so far the Government has not taken a decision.

The penetration of videocassette machinery into Australian homes is about 35%, and increasing at the rate of 1% per month. Hire of pre-recorded videocassettes has grown rapidly. There is now a video shop in every town and suburb. Videohire has an advantage in that the television programme replay is at the customer's convenience, whereas pay television programmes delivered by broadcast communications is only available at set times within a schedule of programmes. Therefore it appears that videohire has now largely pre-empted the demand that might have existed for Pay Television in Australia.

6. CONCLUSION

Australia is no different to many other countries around the world in that the future of the entrenched telecommunication monopolies is being extensively examined. During the last decade there has been a sequence of Inquiries, the Reports of which are listed in the Appendix.

As a direct consequence of these Inquiries, Australians are now well-informed concerning the existing state of their country's telecommunications and broadcast communications compared with other countries around the world, its deficiencies and inequalities, and the opportunities that the new technologies offer.

Already, Australia has made a cautious start along the road of liberalisation. Initiatives, such as HACBSS and RCTS are an endeavour to resolve the deficiences of existing broadcast communications. The Government has shown flexibility in addressing such matters. For example, policy for SPS, HACBSS and RCTS has evolved through consultation and discussion over several months, and it may not yet be final. Australians are looking forward to further Government decisions for the development of broadcast communications in Australia, either by the adoption of new technologies or restructuring of existing arrangements, as recommended in the Reports of recent Government Inquiries.

APPENDIX

Reports of official Inquiries relevant to Broadcast Communications

1. Commonwealth Government Task Force Report entitled "National Communications Satellite System" July 1978.

2. Working Group Report "National Communications Satellite System" August 1979.

3. Report by the Committee of Review of the Australian Broadcasting Commission entitled "The ABC in Review, National Broadcasting in the 1980's" May 1981.

4. Report by the Australian Broadcasting Tribunal entitled "Cable and Subscription Television Services for Australia" August 1982.

5. Report of the Committee of Inquiry into "Telecommunications Services in Australia" October 1982.

6. Report by the Australian Broadcasting Tribunal entitled "Satellite Program Services - Inquiry into the regulation of the use of satellite program services by broadcasters" July 1984.

7. Report by the Department of Communications "Localism in Australian Broadcasting - A Review of Policy" August 1984.

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DIGITAL TELECOMMUNICATIONS IN NEW ZEALAND

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1. Abstract

Like many other nations New Zealand has already charted a development path towards the digital world.

Despite its small size and low population density, New Zealand enjoys a wide range of high quality telecommunication services. This has provided a firm foundation for the application of digital technology and the development of new information services.

This paper describes the current state of evolution of digital telecommunications in New Zealand, the impact of the technology on user services and the organisations that are responsible for its development.

2. NEW ZEALAND TELECOMMUNICATIONS

2.1 INTRODUCTION

New Zealand's geographic remoteness from other nations has resulted in the early development of high quality national and international telecommunication services. Today, despite its small size (about ¼ million square kilometres) and small population (just under 3.3 million), New Zealand's communication services rival those of virtually any other developed nation.

96% of households have a telephone. 98% have a television receiver. At 31 March 1984 97.2% of all telephone subscribers had automatic service and 65.3% had subscriber toll dialling (STD) and international subscriber dialling (ISD). 96.2% of all subscribers also enjoyed toll-free calling with their nearest town or city centre.

In addition, nationwide telex, telepaging, facsimile, land and maritime mobile, and data services (including packet switching) are all available.

Furthermore the prices paid for these services, while not the lowest in the world, do compare favourably with those of other developed nations (Fig. 1).

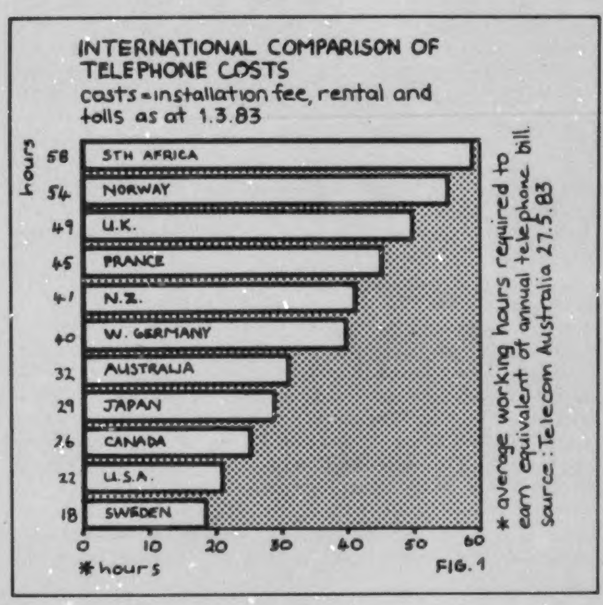

FIG. 1

2.2 HISTORICAL DEVELOPMENTS

In the beginning there were no people in New Zealand. Ages after other nations had been settled, New Zealand was uninhabited. The first settlers came from other Pacific Islands - initially the moa hunters and then the Maori. They called the land Aotearoa (land of the long white cloud).

Some six centuries later the Europeans (the pakeha) arrived, bringing with them infinitely more sophisticated technology as well as new structures and organisations for applying them.

With the invention of the telegraph in 1845 and the telephone in 1876, New Zealand already had in place the civil structures to put to use these emerging technologies. As a result, New Zealand's first telegraph service went into operation in 1862 and the first telephone service in 1881.

International services have developed at a similar pace. The first New Zealand submarine telegraph cable was laid from Nelson to Sydney in 1886, only 25 years after the first in the world across the English Channel. In 1971 New Zealand commissioned its first satellite earth station, less than 10 years after the first experimental communications satellite was launched.

New Zealand's entry into the digital age has been equally rapid. Digital pair-gain systems were first used in 1972 and during the last three years digital telephone exchanges, digital microwave systems, electronic PABXs as well as digital coaxial and optical fibre cable systems, have all been introduced.

New Zealand is making rapid progress initially towards an Integrated Digital Network (IDN) but ultimately towards an Integrated Services Digital Network (ISDN) [1,2,3,4].

This paper describes the application of digital technology in New Zealand and the impact it is having on key sectors of New Zealand society.

2.3 THE COMMUNICATIONS CHALLENGE

In New Zealand, the challenge in the provision of communication services comes from the land. Even though New Zealand is dwarfed by the huge land masses that make up the major continents around the Pacific rim, its land area is large compared to the population. In addition, much of the terrain is mountainous and quite inaccessible. While communication solutions have been found for all but the most remote locations, they have not been inexpensive.

The land has shaped the people too. It has determined the type of housing, the modes of transport, the population's diet, as well as attitudes to work, travel, sport and cultural pursuits.

From this has emerged an expectation that basic communication services (telephone, radio, televison) should be available to all New Zealanders at a uniformly low price. As recently as 1960 there was a vision that all New Zealand would one day be included in a single free calling area. This vision resulted in a steady expansion of free calling areas during the 1960's and early 1970s. However, during recent years efforts have been made to restrict the growth of free calling to well-defined communities of interest and to retain individual call charging for all other calls.

Nevertheless, the use of rate averaging has enabled the realisation of high quality and affordable telecommunication services to all sectors of society.

The land has also shaped New Zealand's economy and its industries. First and foremost New Zealand is dependent on its primary industries - wool, lamb, forestry, milk products, beef, fishing and horticulture. Almost invariably, the production of these commodities is carried out on individually owned and operated farms, most of which are widely separated. Unlike many other countries in which farmers live together in small communities, the New Zealand pioneer farmer, because of the distances involved, had to live alone in remote homesteads. But no sooner were these pioneers established than they turned their attention to ending their isolation. Roads were built; a railway system was built; a telecommunication network was developed.

Today telecommunications play a growing role in not only reducing this isolation but also in bringing farm products to the marketplace both within New Zealand and overseas.

But, even though New Zealand's economy is still based on primary industries, fewer and fewer people actually work on the farms. Most New Zealanders live and work in the cities. Inner city Auckland and Wellington, with their high rise office blocks, look much like any other major city in the world. And the work that is carried out in these office blocks is also much the same as in other countries. Modern telecommunication services are just as important to the office worker.

Although the pakeha dominates New Zealand society, the Maori and Polynesian cultures have influenced the creation of a relaxed and casual lifestyle, a characteristic that is most noticeable to the visitor to New Zealand.

Leisure time is important to the New Zealander and communication services play a key supporting role.

For example, a sophisticated computer network operated by the Totalisator Agency Board [13] has stimulated the growth of the horse racing industry, providing both new jobs and world class horses [5].

Low cost portable two-way radio communication sets allow trampers to explore the beauty of New Zealand's bush country, yet still be able to summon help in case of an emergency. Similarly, maritime mobile services around the coast of New Zealand provide a dimension of safety to a popular leisure activity.

New Zealand is also a nation of many nationalities. During recent years in particular there has been a mass migration from many of the South Pacific Islands to New Zealand - from Niue, Western Samoa, Tonga, and the Cook Islands. Some islands now have more of their people living in New Zealand than at home. The effect of this migration has been to strengthen ties between New Zealand and the neighbouring Pacific Islands both for family reasons and for trade.

This in turn has stimulated the demand for high quality telecommunication services. With the exception of Niue, these islands are now all linked to New Zealand by satellite.

Recognising the importance of telecommunications in social and economic development, New Zealand has made a special effort to assist the developing nations of the South Pacific establish their own networks.

This assistance has been in the form of direct financial aid and through expert assistance in particular for local training programmes.

3. APPLICATION OF DIGITAL TECHNOLOGY

3.1 PCM CARRIER SYSTEMS

The first digital application in the telephone network was pulse code modulation (PCM) equipment for providing inter-exchange junction links. Initial systems were based on the North American 24 channel standard (1.544 Mbit/sec) but in the late 1970s New Zealand adopted the 32 channel systems (2.048 Mbit/sec) as standard.

This decision was not an easy one but with hindsight was crucial to the future development of digital systems in New Zealand. There was already a substantial investment in 24 channel equipment, not only in the physical plant but also in staff training. Furthermore, digital span lines had been set up with regenerators spaced for 1.544 Mbit/sec working. The shift to 2.048 Mbit/sec working involved building new digital span lines with different regenerator spacings.

To maximise the utilisation of existing span lines and keep maintenance costs down, all the PCM24 equipment was concentrated in one engineering district. This strategy has worked well with a minimum of wasted effort. The PCM24 equipment is now reaching the end of its economic life and will gradually be phased out altogether (Fig.2).

3.2 DIGITAL EXCHANGES

The next step towards a digital network was taken at the beginning of 1982 with the introduction of the first Stored Program Control (SPC) digital telephone exchange.

Today, just 3 years later, we have installed nearly 80 SPC digital exchanges with a further 30 programmed to cutover this year (Fig.3).

New Zealand has been able to leapfrog the SPC analogue stage of development by moving directly from electro-mechanical crossbar equipment in the 1970s to digital equipment in the 1980s. In 1979, world tenders were called for the supply of new switching equipment. The specification was originally written for analogue equipment but just before publication digital switching systems were being announced. A digital option was therefore added to the specification. The digital equipment offered proved to be competitive with the analogue and therefore the digital choice was straightforward. While approximately half of the SPC exchanges installed to date have been small rural units (less than 1000 lines) an increasing amount of effort is now being put into building an infrastructure for an integrated digital network. By 1986, 75% of all major cities in New Zealand will have digital primary or secondary exchanges.

All SPC exchanges in New Zealand are supplied by NEC Corporation of Japan. NEAX 61 equipment is used for the larger local exchanges (LXs), as well as the primary (PX) and secondary (SX) exchanges. NEAX 61S equipment is used for the smaller rural exchanges.

3.3 DIGITAL MICROWAVE RADIO

Another key element of the growing digital network is a high capacity backbone trunk system. The first segment of this, linking Auckland and Wellington, a distance of some 650 kilometres, was cutover late in 1984. Both digital microwave and digital coaxial systems are used along this route to provide a 140 Mbit/sec path. Existing coaxial cable links Auckland-Hamilton and Palmerston North-Wellington were converted to digital working and seven new digital microwave stations were constructed to link Hamilton and Palmerston North.

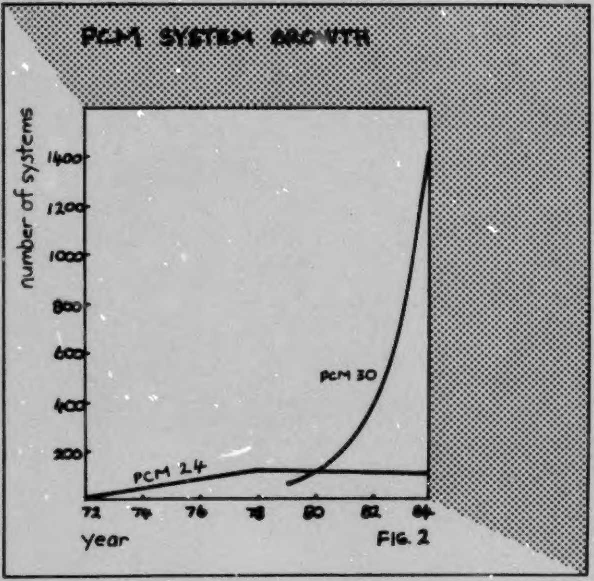

FIG. 2

Planning is also well advanced to extend the digital backbone to Christchurch, Dunedin and Invercargill. A portion of the South Island route will also use optical fibre cable.

3.4 OPTICAL FIBRE CABLES

The first optical fibre cable system in the New Zealand network was commissioned in 1983. The 140 Mbit/sec system can provide 1920 telephone junction circuits over a distance of 14 km without regeneration. The second system, using cable manufactured in New Zealand was commissioned during 1984. This cable runs from the New Plymouth power station to the Spotswood telephone exchange 2.5 kms away. More than 20 further projects are planned within the next few years (Table 1).

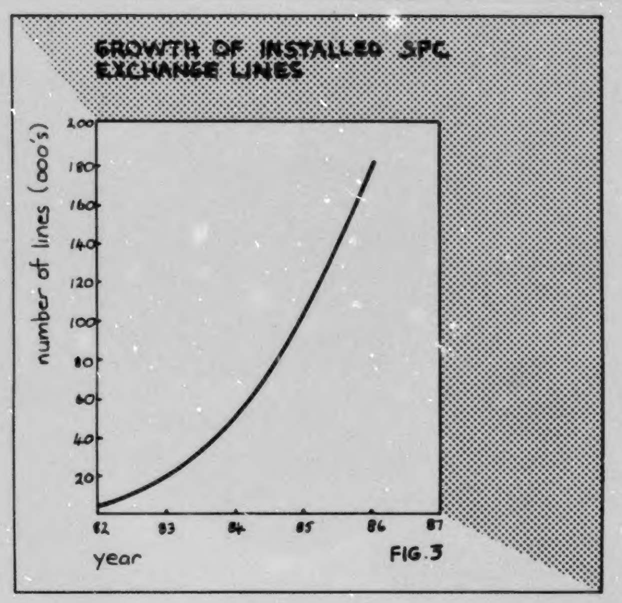

FIG.3

When	Where	Length km	No. of Fibres	Capacity Mb/s
1983	Wellington	14	4	140
1984	New Plymouth	2.5	4	2
1984	Gisborne	2	10	140
1985	Wellington	8	20	140
1985	Auckland	11	24	140
1985	Nelson	4	10	140
1985	Auckland	27	24	140
1985	Auckland	20	10	140
1985	Hamilton	30	10	140
1985	Hamilton	23	6	34
1985	Taumaranui	41	4	8
1985	Taumaranui	21	4	8
1985	Napier	6	10	140
1985	Wellington	4	10	34
commencing 1985	Canterbury Plains	323	4-12	140/565
commencing 1985	Palmerston North	406	6-12	140/565
1985	Dunedin	4	10	140
1985	Invercargill	13	8	140
1985	Auckland	24	24	140
1986	Auckland	24	10	140
1986	Auckland	14.5	10	140
1986	Napier	8	4	34
1987	Auckland	21	10	140
1987	Rangiora	29	4	34

Table 1 Optical Fibre Projects [7]

3.5 DIGITAL PABXs

Quite independent of these digital developments in the public telephone network there is also a growing demand for digital PABXs for office communications. Three digital systems are marketed by the Post Office - the Maxinet (CDSS1 from GEC), the Multinet (SL-1 from Northern Telecom) and the Ultranet (SX-2000 from Mitel). The digital PABX is providing a cost effective solution for modern office communications as well as providing a hub for the office of the future.

For the scale of business activity generally encountered in New Zealand the PABX twisted pair is more than adequate for most intra-office data communications.

The expected growth in digital PABXs is illustrated in Fig.4.

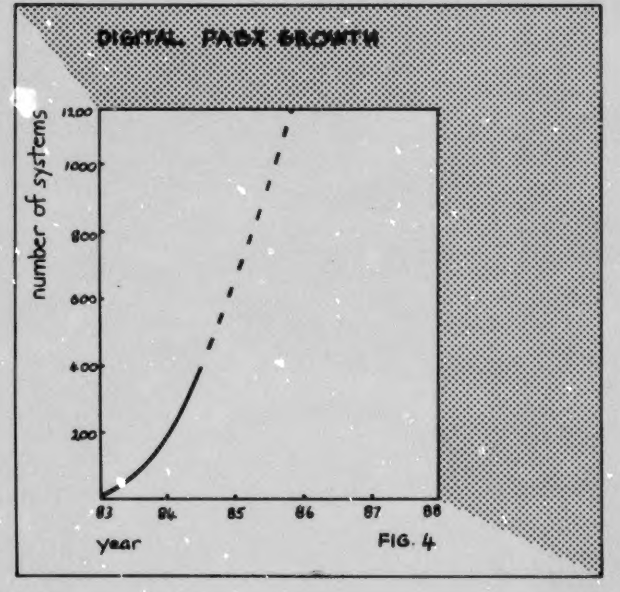

FIG. 4

3.6 LOCAL LOOP

The final link in the digital network chain - the local loop - is already in sight. Digital equipment is already being used to provide telephone service to remote rural communities. The first two multi-access radio systems, which provide shared use of 15 radio channels for up to 170 subscribers, are now in operation and others are planned.

PCM equipment is also being used to provide a 2Mbit/sec path for large data applications. However the major step in local loop digital system is expected later this year with the provision of a 64 kbit/sec path between customer premises in many of the main centres. Tenders for the supply of suitable equipment were under preparation late 1984.

3.7 INTERNATIONAL

The first step towards international digital communications was also taken in November last year, with the installation of a new SPC digital international gateway exchange in Auckland [8].

During the year both of New Zealand's major international communications facilities were extended. A new satellite earth station was commissioned. This has been designed to work to the new Pacific Region INTELSAT V satellite later this year. The new ANZCAN submarine telephone cable also went into service last year [9].

The growth of New Zealand's international services is shown in Fig.5.

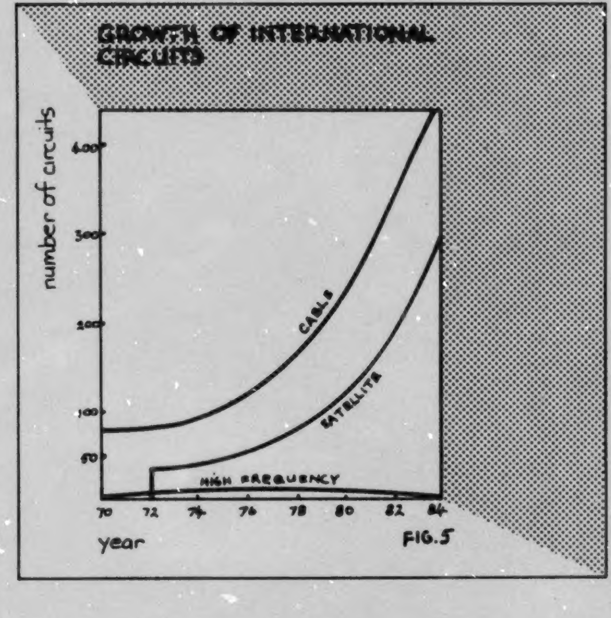

FIG.5

3.8 PACKET SWITCHING

Like many other countries New Zealand has also introduced a packet switching service providing both domestic and international communications. Today the packet switching service is providing an inexpensive data transport facility for emerging new services such as videotex and point of sale electronic funds transfer. For the future, the packet switching service will retain a key role in the emerging digital network. The expected demand for packet switching ports is shown in Fig.6.

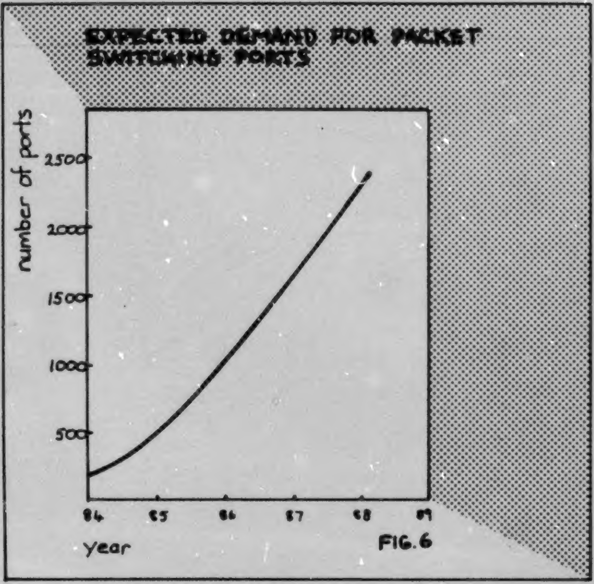

FIG.6

4. SECTOR IMPACTS

4.1 RURAL

There are many remote rural communities spread throughout New Zealand, some of which are not even accessible by road. In the Marlborough Sounds at the top of the South Island for example, the standard method of transport is by boat. Yet there are very few of these communities that do not have basic communication services - telephone, radio and television.

Despite the very high cost of providing communication services in these remote areas, the objective of affordable telephone and broadcast services available to all has been a clear social goal for New Zealand. This has also been important in maintaining and developing the primary industries on which our economy is based.

However, while virtually all the rural community has basic telephone service a small percentage still has manual service or shares a party line (Fig 7).

The challenge now is to provide all these users with individual, automatic service.

Not only do telephone users in the rural community expect a standard of service comparable with urban users but there is also a rapidly growing interest in the use of data services such as videotex for improving farm management. These services require an individual automatic telephone line.

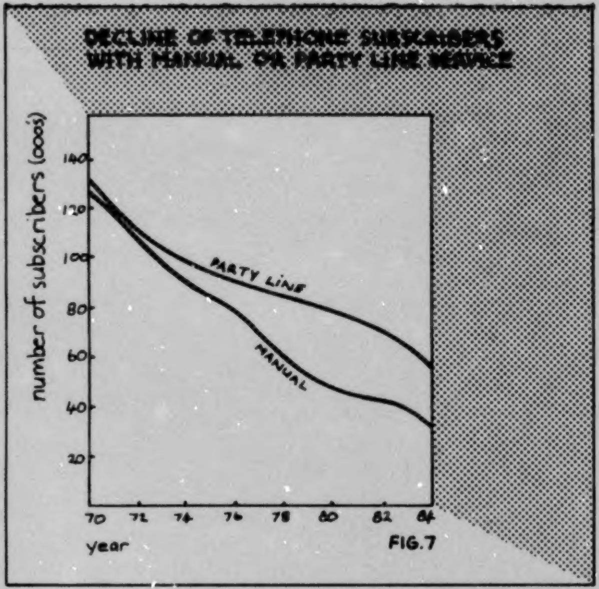

FIG.7

A variety of techniques are being used to meet this challenge, including digital exchanges and digital transmission equipment [10]. For up to 120 subscribers, the preferred methods are subscriber PCM multiplex and multi-access radio. Between 120 and 500 subscribers it is intended to use NEAX 61RS remote switching units, the first of which is programmed to cut over in 1986.

Above 500 subscribers NEAX 61 or 61S exchanges are used. By 1988, using these methods, all the remaining manual exchanges are expected to be upgraded to automatic working.

Complete upgrading to individual service, however will take a little longer. In the past aerial reticulation has been the only available means for serving subscribers distant from an exchange. Underground cabling has been used extensively to upgrade the "near in" subscribers as flat rate free calling areas have steadily expanded.

But there are many situations where the distances are so great that transmission limits can not be met on 0.63mm conductor cable or where cable laying conditions are poor, or where subscriber densities are so low that cable reticulation is uneconomic. In these situations, we have turned to multi-access distributed radio systems and subscribers PCM systems.

For the future, further alternatives will become available. Tenders have just been called for the provision of equipment to establish a mobile telephone service based on cellular radio technology and even though this service will initially be targeted at urban users it may well prove to be an economic alternative for fixed rural services. Even further in the future the possibility of a "homestead" satellite service is being considered. However, because this would not even be a possibility until the early 1990s, planning effort today is concentrating on terrestrial solutions.

The use of digital technology for rural communication services in New Zealand means that the farmer will be able to enter the information age at virtually the same time as the urban businessperson. An individual connection to a nationwide integrated digital network will allow the delivery of information services almost independent of distance. With the recent establishment of packet switching and videotex services in New Zealand, the first steps have already been taken towards distance independent charging.

With the same standard and price of telecommunication service, the farmer will be able to more actively participate in other business activities.

The boundary between urban and rural will become blurred.

4.2 URBAN

The impact of the shift to digital communications in the urban environment has been greatest in the business office.

The new electronic PABXs have not only offered substantial space saving but have also brought to the business user a host of new facilities. Overnight the business telephone has been transformed into a multi-function management tool. The digital PABXs are also preparing the ways for emerging integrated office systems. Even though today's systems are only being used for voice communications, development options are becoming available for providing integrated data switching. Wideband local area networks are also emerging in New Zealand, but it is likely that narrowband twisted pair technology (based on a digital PABX) will meet most office communication needs. The majority of New Zealand businesses are relatively small (Fig.8) and the demand for most data transfer well within the capabilities of existing telephone reticulation (80 kbit/sec).

Basic electronic message business services such as telex are well established in New Zealand; at 31 March 1984 there were 5,257 telex subscribers. Also growing in popularity is a relatively new service - datex. Datex operates at 300 bits/sec (4½ times the speed of telex) and is directly compatible with computer and word processing equipment. Using datex, word processors are able to communicate with other similar machines or they can be used as a telex terminal. Datex is one step towards the multifunction office terminal. In

New Zealand we expect to take further steps this year with the introduction of integrated business workstations and a store and forward electronic message service. We are also planning for the introduction of teletex.

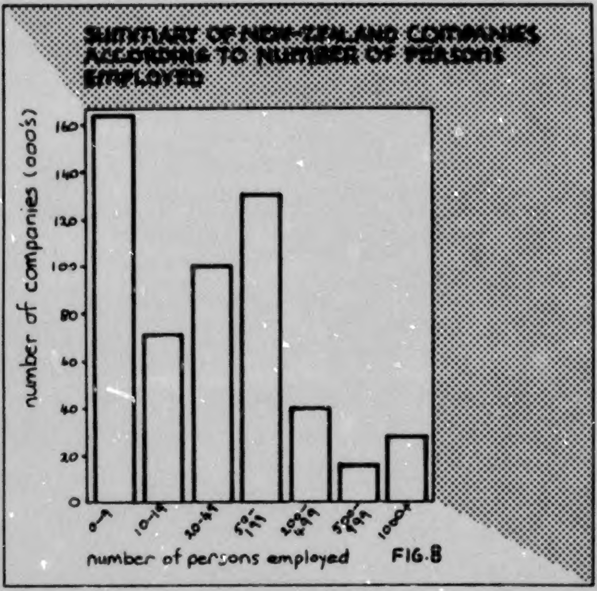

FIG.8

Facsimile services are also well established with over 500 machines in use. The Post Office also provides a public bureau facsimile service (Bureaufax) at 33 offices throughout the country.

However one of the most dramatic areas of growth has been in data communications. For the last three years the growth in leased data circuits has exceeded 30% per annum.

4.3. FINANCE AND RETAIL

The finance and retail sectors are closely linked with emerging telecommunication services. Both videotex and point-of-sale electronic funds transfer systems have already been established in New Zealand and a rapid growth is expected for each (Figs. 9 and 10).

During the initial development period for videotex services in New Zealand, the telephone network has been used as the transport service, but later this year a new system architecture based on the packet switching network will be introduced. Videotex calls will still originate on the telephone network but will then be routed via a Videotex Access Pad (VAP) into the packet switching network. Videotex system operators will connect directly to the packet switching service.

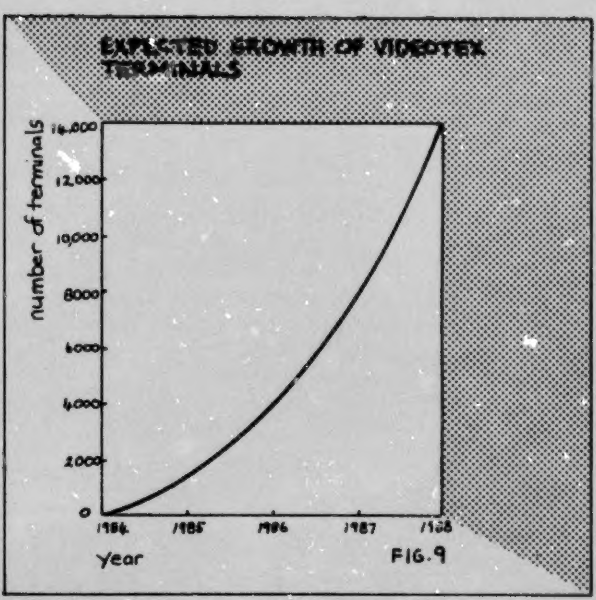

FIG.9

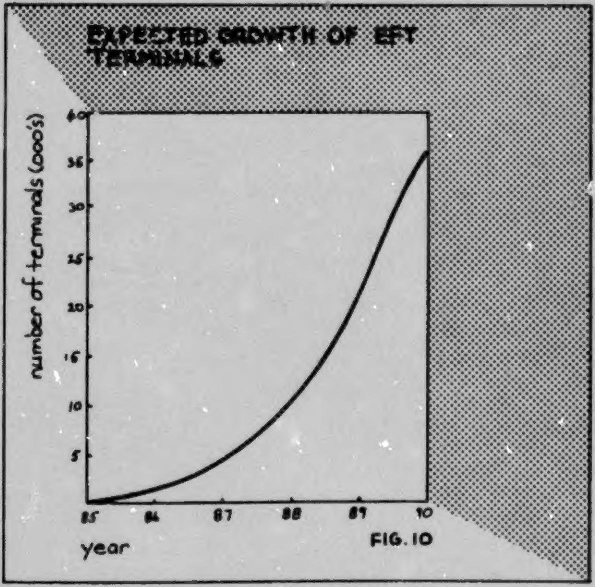

FIG.10

Videotex services are being used by the banks and other financial institutions to provide up-to-date foreign surcharge rates and stock market formation. One operator is also running a home banking trial. In the retail sector videotex services are being used for inventory control and travel information.

EFT-POS systems are also emerging, using the packet switching service as the basic transport network. Three pilot trials are being developed, the first of which is already in operation. Early retail applications are in petrol stations and supermarkets. A matter of concern to the customer has been the potential loss of the 30-40 days free credit that is available using the current credit card system and the associated apprehension that the cost of terminals will be reflected in increased prices. However the very low communications charge for each transaction (in many cases less than 5 cents) is likely to have an equalising effect, acknowledging that the present day cost of cheque clearance is some 60-70 cents. Furthermore the initial applications of EFT-POS are expected to be in situations where cash is normally used, eg. supermarkets, and, therefore direct debiting of an account imposes no additional penalty.

A further concern is that different incompatible systems could emerge. The need for a single terminal at the retailer's premises that is capable of accepting all cards and interworking with all banks and financial institutions has been recognised. At this early stage of development considerable effort is being put into developing strategies that will ensure this goal is realised.

It is evident that the packet switching service will be playing a major role in the development of services for the finance and retail sectors. However, for some activities, private leased circuits will continue to play a key role.

Organizations that are large enough to generate substantial flows of data have found it convenient to use leased Post Office lines and to arrange their own systems so that these lines are then used to full effectiveness. For example, the banking system has two main data processing and clearing facilities but the data preparation is carried out in individual urban centres, transferred to Wellington on leased lines, and summary statements of balances printed out in the same remote centres in time for the next day's activities. The very efficient use of leased lines for the exchange of banking and other corporate data has meant that there is a preference for centralized computer systems since the management costs associated with distributed processing systems have outweighed the costs of the extra communications facilities needed for central processing [11].

4.4 PRIVATE NETWORKS

4.4.1 AIR NEW ZEALAND

Air New Zealand is the government backed overseas airline and also operates, through incorporation of the previously separate National Airways Corporation, most internal air services. The integrated reservation system and data processing system has links with other international operators. The system uses leased lines for its telecommunication links and has been stated to be "not well adapted" to the use of the packet switching network.

One delay apparent to the customer arises when the purchased airline ticket has to be written out. The move is thus towards automatic ticket printing. It has been observed that the load on the computer handling the visual display units tends to shift from ticket sales to increased enquiries on fare prices when economic conditions are tight.

4.4.2 MINISTRY OF TRANSPORT

The Aeronautical Fixed Telecommunications Network (AFTN) is based on a three node meshed network operating dual 9.6kbit/sec circuits Auckland-Wellington, Wellington-Christchurch and Christchurch-Wellington. From these three main nodes, star networks radiate to other centres (150 terminals total) on telex circuits. Although the loading on the high speed circuits is only about 10-15%, the low speed local telex circuits are loaded to 40-80%, approximately 70% of that traffic being predominantly meteorological information.

4.4.3 NEW ZEALAND RAILWAYS

The operation of the railways can be regarded as a multi-tier packet switching communications system. Information on the location of trains and instructions on the routes to be taken are carried on the signalling system which, traditionally and logically, is generally routed along the area available beside the track. In the interests of efficiency, control and cargo information to station and depots is usually carried on a closely associated network. The exception is in the case of VHF communication with train drivers where hilltop sites are used in a system integrated with other mobile communication users.

With the increasing use of electric locomotives, increased electrical isolation of the communications system has become necessary and with the advent of digital systems this is being achieved economically through the use of optical fibres [12].

The identification of wagons using digital electronics and the use of this information in automated shunting centres is of value in improving the general efficiency with which goods can be transported.

Overall control of the system is achieved through computerized stores inventory, track database and general finance and accounts. As well as this, the New Zealand Railways operates a reservation system that covers its rail, ship and bus services. The software for these systems was mostly written in New Zealand.

4.4.4 MINISTRY OF ENERGY - ELECTRICITY DIVISION

The Electricity Department owns and operates its own switched telephone network incorporating 60-70 exchanges employing digital switching technology with analogue interfaces to the outside world. Each exchange has typically 30-70 lines. There are two telephone networks, one being a very secure operational network of 13 exchanges employing closed group numbering and the second network being local area networks. The operational network is based predominantly (67%) on Electricity Department carrier circuits on power line transmission links with the remainder being on Post Office high security leased circuits which are mainly used as backup.

Data communications is limited strictly to that required for power system control and reporting. No data is carried on these circuits as computer communications.

The Electricity Department does own and operate its own mobile radio telephone network, UHF AM system. However a frequency shift will be required with the advent of FM broadcasting in New Zealand and it will be responsible for its own frequency planning within a block of frequencies allocated by the Post Office. The complete system comprises approximately 100 repeaters throughout New Zealand with 2000 mobiles.

4.4.5 MINISTRY OF DEFENCE

The main requirements in the Department of Defence are for -

- rapid and secure fixed network, both internal and overseas
- efficient mobile system

The first is obtained by using encrypted data networks with route diversity employing, for the internal services, lines leased from the Post Office as common carrier.

The mobile system is built around the New Zealand made Tait radio telephones that have proved to be extremely efficient in many different environments.

While Defence has long been a labour-intensive undertaking, the advent of digital systems for the transmission and switching of routine operational information has released a large number of erstwhile switchboard operators etc. for more satisfying types of work. A significant part of Defence operations is concerned with search and rescue undertakings and better communications have improved effectiveness in this field.

4.4.6 POLICE DEPARTMENT

Apart from an internal telephone network which is likely to be upgraded significantly in the near future the most critical areas of communication for the police are mobile communications whether it is in vehicles or with officers on the beat. In the foreseeable future this mobile communication will also be required for data communications giving mobile patrols access to the encrypted records as well as automatic vehicle location reporting.

At present the mobile radio network is a traditional VHF-AM system supported by 200 repeaters throughout New Zealand in many cases situated at shared sites with Post Office or other land mobile base station owners. There are approximately 3000 mobiles half of which would be patrol cars, the other half being in vans or with those officers on the beat.

In the metropolitan areas there is a need for an improved method of linking repeater sites and it is proposed to employ a multi-access, demand assignment digital interconnect network as an additional layer on top of the repeater-mobile communication links. This is seen as an efficient, economic and flexible solution to the present problem and may be a unique solution in New Zealand to the problem of interconnecting repeater sites.

4.4.7 GOVERNMENT COMPUTER NETWORKS

The Computer Services Division of the State Services Commission runs four large computer centres and four data preparation centres, and owns an engineering and science computer which is run on behalf of the Commission by the Ministry of Works and Development. These Centres together, support a communications network of over 2500 screens throughout New Zealand which are linked by 43,873 kilometres of Post Office circuits.

If other departments with their own mainframes and networks are included, the present total would be in the region of 4000 terminals in the Public Service.

In addition to the networks run by the State Services Commission, other large departments in the public sector have extensive systems some of which are mentioned elsewhere in this paper, e.g. Railways Corporation, Health Department, Defence Department, Department of Scientific & Industrial Research, Ministry of Transport, Statistics Department, Ministry of Agriculture and Fisheries, National Library, Post Office, NZ Forest Service, Department of Lands & Survey.

Some of these organisations have plans to increase considerably the number of screens attached to their systems, and over the next five years there could be in the region of a 300% growth in overall network size, which will give a total of some 12,000 terminals throughout the Public Service.

4.5 LOCAL MANUFACTURING

New Zealand has a comparatively recent history of indigenous manufacture of communications equipment. Traditionally New Zealand's telecommunication equipment needs have been imported from the UK, Europe, the USA and Japan. However the domestic electronics industry is now an important part of the national economy. New Zealand manufacturers have demonstrated that they can meet local telecommunication needs and that they are very successful in gaining export orders.

This is most evident with a wide range of mobile two-way radio products; mobiles, portables, repeaters and base stations from Tait, AWA, Philips and Plessey. Then there is the Philips SBZ range of Samll Business Communication Systems covering the 4 to 12 extension; 2 to 5 trunk market, a locally designed cost effective micro-computer controlled switch of modern design and with features to match.

NEC and the NZPO are partners in a joint venture enterprise dedicated to the production of software for the NEAX 61 digital telephone exchange equipment, both for the local and export markets.

Philips and Delphi Industries are active in design and manufacture of a range of leased line and switched network data modems in the 300BPS to 2400BPS range.

AWA manufacture a locally designed "country-set" radio telephone link - a modern microprocessor controlled single channel link designed to connect a remote telephone subscriber to a telephone exchange via radio.

Mitel, GEC and STC are manufacturing, under license, PABX's covering, between them, the 12 to 500 extension capacity requirements. Similarly STC and Philips are manufacturing telephones; STC the new standard phone in 150,000+ annual quantities and Philips two of the decorator series in 50,000+ quantities.

Austral Standard Cables Ltd is producing a wide range of communications cable and wire and has recently extended its expertise to include production of optical fibre cable.

The complete range of products and their local manufacturer is too numerous to list; however, additional to those already mentioned, are products such as telephone keypads, subscribers carrier systems, power supplies, loading coils, line amplifiers and communication antennas.

5. SOCIAL IMPACTS OF DIGITAL COMMUNICATIONS

5.1 COMPUTERS IN COMMUNICATIONS

The use of digital systems has meant that computer-like equipment is now associated with the traditional telecommunications network. Communication systems must be kept operating, so high standards of reliability, inter-changeability and compatibility are essential. There has not been the same tradition of compatible industry standards and long projected operating life in the computer industry. Their close association now enforces the adoption of such standards, particularly of compatibility, and this in turn opens the way for local electronics manufacturers to supply parts of the system. The adoption of the standards of quality appropriate to the telecommunications system can only be beneficial to any electronics industry.

5.2 COMPUTERS IN AN AGRICULTURAL INDUSTRY

The New Zealand economy is still predominantly based on agriculture but the flexibility of this sector in the face of changing market requirements is being enhanced by the use of information retrieval and recording systems. The day-to-day efficiency of operation of most agricultural and horticultural sectors is being significantly improved through the use of automatic control, monitoring and management systems associated with the keeping of breeding and performance records for example.

5.3 TELETEXT

Television service in New Zealand comprises two channels provided by the Broadcasting Corporation of New Zealand and Teletext is included on both of these channels [13]. A large part of the impetus for the introduction of Teletext came from its value as an aid to disabled persons and some of the initial funding was raised by public subscription. Some New Zealand made programmes are being produced with Teletext captions. Some commercial content is being introduced in order to make the system self-supporting and to contribute towards the extra cost of captioned programmes. Although New Zealand broadcasting is traditionally free of advertising on Sundays, advertising has been included on the Teletext service for the full 7 days each week on a trial basis.

Because of New Zealand's large areas of hilly terrain, many viewers accept TV pictures of less than perfect quality but the digital Teletext is somewhat sensitive to short term reflections in the received signal. The extent of this problem and the tandem performance of translator stations is presently being assessed.

The Teletext service provides some 450 pages of information. 200 of these are base pages, the rest are rolling pages. The type of information available in the service consists of News, Weather, Sports News, TV Programme Guide, What's on Guide, Travel News, Finance, Features and Consumer News. Pages of Information for Disabled Viewers are also available.

6. INTEGRATED PLANNING

6.1 INTRODUCTION

An underlying theme of New Zealand's communications both in telecommunication and broadcasting has been that of a nationwide availability of services provided at a universal flat rate rental. This policy is due in no small way to the economic and therefore political importance of the rural sector in New Zealand. To ensure that this policy of universal service was not abandoned Governments have, until comparatively recently (last 10 years), maintained a monopoly on the provision of broadcasting and telecommunication services.

In an environment of Government monopolies on communications little overall coordination is necessary by other than individual organisations. However, with the emergence of private broadcasting, and the rapid development of technology making options available in the communications field varied and complex with uncertain social impacts, the need for input to Government from other than the traditional government agencies was a necessity. This section explains the role of the various organisations which play a part in the planning of communications in New Zealand.

6.2 THE NEW ZEALAND POST OFFICE

The New Zealand Post Office is the only organisation in New Zealand permitted to provide a public telecommunications service. Under the Post Office Act, 1959 it is permitted to establish and operate telephone and telegraph communication services in New Zealand and negotiate international arrangements. Services can include the leasing or hiring of circuits and/or equipment with telegraph communications being defined in the broad context as communications transmitted to a distance by any apparatus other than a telephone.

The Act provides for the Post Office to license and regulate radio stations and apparatus and license private lines and communications systems. This separate regulatory role of the Post Office is carefully divorced from its commercial role, being performed by an autonomous group within the Engineer-in-Chief's office of Post Office Headquarters.

The Government has maintained what is essentially a universal flat rate telephone rental policy and maintains a high standard nationwide telephone service even to remote rural areas. The policy of maintaining the Post Office as the common carrier ensures that this situation can continue. New Zealand's network is to a large extent a long narrow backbone trunk network with little scope for the efficiencies to be gained from competition in basic telecommunication services. This is in contrast to the high density mesh networks in those countries going down the path towards deregulation.

The Post Office, as the common carrier and the local telephone operator, has sole responsibility for the design, operation and performance of the network whether it be for telephone, data or other miscellaneous services, domestic or international. It therefore represents New Zealand at International Telecommunications Union Consultative Committee meetings and is a signatory to the INTELSAT agreement on behalf of the Government.

6.3 THE COMMUNICATIONS ADVISORY COUNCIL

The Communications Advisory Council [14] was established in 1978 following a Communications Commission report that recommended the formation of such a group to "provide for the coordination of telecommunication planning". The CAC is supported by a small Planning Unit and its terms of reference include a responsibility to -

- formulate, coordinate, review and recommend longer term national telecommunications policies and monitor their implementation;
- ensure balanced consideration of each telecommunication sector as an entity as well as in comparison with all others;
- ensure adequate information and statistics appropriate to the Council's responsibilities are available and to undertake or commission such studies as required;
- consult and liaise with other national authorities, organisations or interests as required;
- ensure that the broader aspects of technical standards are considered in relation to economics;
- advise on public relations in regard to overall telecommunications policies and development.

The current membership of Council is 11 with members appointed by Cabinet on a personal basis, being key people drawn from a broad cross-section of the public and private sector groups in the communications industry. The sectors from which current members are drawn are, newspaper industry, Post Office, Ministry of Defence, manufacturers, Department of Scientific and Industrial Research;

Broadcasting Corporation, trade unions, tertiary education, electronic manufacturers with export as a priority, and computer industry.

Council, since 1978, has reported to its Minister on a wide variety of subjects from the provision of videotex services to the impact of satellites on New Zealand's communications. Some reports, being primarily advice to Council's Minister, have remained confidential but in many cases its reports have been published to ensure that interested parties are kept informed.

6.4 BROADCASTING TRIBUNAL

The Broadcasting Tribunal was established under the Broadcasting Act, 1976 - "to consider and adjudicate upon applications for warrants to establish and operate broadcasting stations and other applications relating to warrants" - the reason being that - "Before a person (including the Corporation) is granted a licence under the Post Office Act 1959 to establish and operate a broadcasting station (not being a short-wave station or a relay station), he shall obtain a warrant or authorisation under this Part of this Act".

The Broadcasting Tribunal has also acted in an advisory role to its Minister playing a very important role in deliberations over the question of ownership and operation of a third television channel.

6.5 THE BROADCASTING CORPORATION OF NEW ZEALAND

The Broadcasting Corporation, the government broadcasting organisation, owns and operates through Television New Zealand, two nationwide broadcast television channels, the only broadcast television in New Zealand. The most widely reticulated channel, TV1, serves 99.96% of the population while TV2 can be received by 97.4% of the population.

To ensure such high penetration for TV1 alone requires some -

- 7 high power area stations
- 19 medium power area stations
- 37 low power area stations
- 355 "pocket" stations

even though there is a potential of only approximately one million households.

The broadcast radio network operated by Radio New Zealand is based mainly on three major networks, national, concert and community. The national and concert stations are predominantly networked with some breakouts for local programming whereas the community network is predominantly based on local programming with limited networking for news and items of national interest. Radio New Zealand also provides coverage by at least one station to approximately 99% of the population with a total of 62 stations using 95 transmitters. The Corporation is now progressively converting the concert network to a VHF-FM network.

The near saturation coverage achieved by television and radio broadcasting, bearing in mind the low population density, is significant. The reason for this is the requirement in the Broadcasting Act of 1976 for the BCNZ -

> "To carry on public broadcasting services, and to develop, extend, and improve those services in the public interest; and in particular -
>
> (i) To ensure that Radio New Zealand provides a radio broadcasting service as far as practicable for the whole of New Zealand.
>
> (ii) To ensure that TV1 and TV2 each provides a television broadcasting service as far as practicable for the whole of New Zealand."

Programme distribution for television is a function of the BCNZ themselves using an extensive nationwide microwave network and television translator/repeaters. Radio programmes however are distributed primarily on leased Post Office circuits.

6.6 PRIVATE BROADCASTING

Private broadcasting is limited to radio broadcasting, there being 19 MF stations (including 5 repeaters) and 3 VHF FM stations. Private broadcasters have formed the Independent Broadcasters Association which represents the interests of private broadcasters and makes submissions on various issues to the Broadcasting Tribunal.

The prospects for private television broadcasting are promising with the Broadcasting Tribunal having recommended to Government early in 1983 that a third, regionally based channel should be owned and operated by the private sector subject to a limitation in cross media ownership. Private sector television involvement to date in New Zealand has been limited to programme production for broadcasting organisations and other video production applications such as marketing etc.

6.7 CHAIR OF COMMUNICATIONS

In 1983, World Communications Year, it was decided to establish a Chair of Communications as a permanent mark of recognition of the place communications plays in New Zealand society. The Chair, named in honour of His Excellency the Governor General, will be known as the "David Beattie Chair of Communications".

New Zealand is already well provided for with tertiary education in the communications engineering field. The establishment of this Chair at Victoria University in Wellington will add a new dimension with the study of the broader aspects of policy and social impacts which are being increasingly recognised as a most important consideration in an area where technological developments know no bounds.

7. CONCLUSION

The basis of New Zealand's economy is changing at the same time as the technology. With the benefit of an equable climate, agriculture became the dominant and in many ways the most profitable undertaking in New Zealand so that economic and therefore political influence was held by the farming community. This meant that attention had to be paid to the needs of the widely dispersed farming community by the communications authority. With the growth of large urban concentrations and the diversification of industry much attention has also had to be paid to business interests - large free-calling areas and data transmission, for instance. Demands from these sectors are growing at about the same time as the growth of digital technology so that New Zealand is ideally placed to gain most benefit from the economic advantages conferred by the new techniques. The major planning problem is thus to achieve an equitable balance between maintaining and improving services to the rural community while satisfying a demand for enhanced services in the urban area.

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Teletrack

CHANGES IN THE JAPANESE TELECOMMUNICATIONS INDUSTRY and THE OPPORTUNITIES CREATED FOR FOREIGN FIRMS IN JAPAN

Rodney B. Harada

With the breakup of AT&T, the Nippon Telegraph and Telephone Public Corporation (NTT) is now the largest telecommunication common carrier in the world. However, NTT and the rest of the telecommunications industry in Japan are undergoing many necessary changes to enable them to effectively provide the telecommunication services that Japan will demand in the future. These changes are creating many opportunities for foreign enterprises willing to make the effort needed to compete in the Japanese market.

TELECOMMUNICATIONS IN JAPAN

Brief history. Japan's age of modern telecommunications began in 1854 when Matthew Perry gave the Tokugawa shogunate a Morse telegraph set as a gift from the American president. The Meiji government, which directed Japan's industrialization and modernization in the 19th century, made the establishment of telegraph service one of its top priorities when it came to power in 1868. One year later, public telegraph service was established between Tokyo and Yokohama. Service rapidly expanded to other parts of Japan as well. International telegraphic service was begun between Japan and Europe in 1873 with the completion of submarine cables to Shanghai and Vladavostok. A nationwide telegraph network was completed in 1878. [25, 68]

In 1877, the telephone was introduced to Japan, one year after its invention in the United States. The first general public telephone service was provided in 1890 with the inauguration of service between Tokyo and Yokohama. Telephone service also quickly expanded to other cities in Japan. [25]

The Kanto Earthquake of 1923, which measured 7.9 on the Richter scale, caused extensive damage to telegraph and telephone systems in Tokyo and Yokohama. In reconstructing the facilities, the government introduced modern step-by-step automatic switching equipment (both Siemans Halske and Stowger technologies were employed). [69] Telecommunications systems were originally established by importing advanced technology and equipment from Europe and the United States. However, Japanese companies soon began to manufacture telephone sets, switching and transmission equipment, and other equipment on their own, which they supplied to the government telecommunications agencies.

Ever since 1878, the central government has provided domestic telegraph and telephone services. Control of domestic communications has been vested in a number of different government agencies. [60]

NTT. The peace treaty that went into effect in 1952 ended the Allied Occupation and allowed the reorganization of telecommunications services in Japan. NTT, the present provider of domestic telecommunications services, was formed by the Nippon Telegraph and Telephone Public Corporation Law passed by the Japanese Diet in 1952. This law gave NTT control over telecommunications activities within Japan. NTT, was formed as a public corporation under the authority of the Ministry of Posts and Telecommunications. The same bill authorized the creation of the Kokusai Denshin Denwa Company, Limited to handle telecommunications between Japan and the rest of the world. [63, 69]

At the end of the Second World War, only a half a million telephone sets remained in use in Japan. [38] In addition to rebuilding the war-damaged facilities and providing basic quality telecommunications services to the Japanese people, NTT set two major long-range goals at its inception in 1952: (1) the ability to respond immediately to applications for new telephones and (2) the completion of a nationwide network of automatic telephone exchange systems. [57] By the end of fiscal year 1981, it could be said that NTT had achieved those goals: Direct Distance Dialing had become universal in 1979 [63], unfilled applications for service was down to an insignificant number, and there was an installed base of 58,680,000 total telephones by March 31, 1982. [44]

On January 6, 1981, Japanese Prime Minister Suzuki called Hisashi Shinto out of retirement to become the president of the problem-filled NTT. Hisashi Shinto had spent more than fifty years in shipbuilding and heavy industry where he rose to the presidency of Ishikawajima-Harima Heavy Industries between 1972 and 1979. There he introduced many management innovations that helped make the company one of the world leaders in its field. [31, 35, 55]

In Japan, promotions usually take place from within an organization, so it is a rare occurence when someone from outside the organization is allowed to assume the head job. An outsider is usually only given the presidency when there is a crisis or major changes must be undertaken. That was the situation at NTT when Shinto was named president. The previous president had been pressured to resign when an expense account padding scandal involving high-level officials at NTT and some supplier companies was revealed. In addition to restoring NTT's reputation, Shinto was given the difficult tasks of opening up the procurement system to allow more foreign and non-NTT family telecommunications manufacturers to compete for supply contracts, transforming the bureaucratic public corporation into a more efficient semi-private company, and preparing NTT for the 21st century by overseeing the completion of a totally digital national telephone system for Japan.

Denden family. In the typical Japanese arrangement among corporations, most of a firm's business is distributed among reliable, long-standing suppliers, who are in turn assured of sales to long-term customers. This has been the case at NTT. According to the U.S. Commerce Department, between 200 and 300 companies supply NTT, with about fifty percent of total sales going to only four firms — NEC Corporation, Fujitsu Limited, Oki Electric Industry Company Limited, and Hitachi Limited. The four big companies, together with about 17 medium-sized companies, control about 80 percent of domestic Japanese telecommunications equipment production. Collectively, NTT and the big four suppliers and their subsidiaries are often referred to as the "Denden Family" (in Japanese, NTT is Denshin denwa kosha or Denden kosha for short), because of the close working relationship among them. [63]

Every year, about 2000 management-level employees retire from NTT at age 58. Many of them move into advisory positions in the private sector, similar to the situation of U.S. military generals and admirals. This is called amakudari in Japanese or literally "descending from heaven." This practice is one of the reasons the relationship between NTT and its main suppliers is so close. [17] Many of the directors of "family" companies are former NTT employees. For example, in 1978 the president and one director of Oki Electric, two directors of Fujitsu, one director each of NEC and Hitachi, and a number of directors of their subsidiaries were all former NTT executives. The main reason for the amakudari is to create a liason between the manufacturer and NTT, without which the supplier would be less effective in competing for NTT orders. [17]

Other reasons for the close relationship between NTT and its suppliers are their long history of working together and the practice of cooperating on joint research and development projects. The domestic telecommunications equipment manufacturing industry was virtually built by NTT, which selected certain firms and worked closely with them to develop advanced telecommunications products. This worked well in bringing the industry to a high level of technical achievement, but it also tended to create an overdependence on NTT as a customer and may have impaired the companies in competing in foreign markets. For example, NTT used crossbar switching systems extensively, and Japanese suppliers, who had concentrated on filling those needs, fell behind other foreign firms in the development of more advanced digital central exchange switching systems not used by NTT. [63]

NTT is prohibited by law from doing its own manufacturing. However, it does do extensive research in advanced telecommunications technology and often cooperates with selected producers to develop new products for use. Usually, new products are developed in one of NTT's four Electrical Communications Laboratories. The newest lab was opened in 1984 and specializes in the development of semiconductor device technology and other future microelectonics. [41] NTT also announced plans to establish a software laboratory to coordinate software development projects now undertaken by different sections at NTT. The new lab is expected to help standardize the design of basic software and elevate software development efficiency at NTT. [42]

Some of the basic research is conducted by NTT alone. More often, however, it is carried out in collaboration with one or more other companies, which assign staff to work at NTT labs for the duration of the research project. Upon successful completion of the project, NTT purchases the product from all the involved companies. [48, 53] Formerly, such joint R & D projects were carried out only with companies of the NTT "family"; however, as a result of pressure from manufacturers outside this closed procurement system, NTT is now permitting non-"family" suppliers to compete for its business.

R & D expenditures accounted for approximately 88.5 billion yen ($350 million) in fiscal 1982 or roughly 2.1 percent of total revenues. [15, 45] Research is focused on the technologies required to make the all-digital information network system a reality. Research is underway in the following fields:

- Digital technology
- Optical fiber technology
- Satellite communications
- Very large scale integrated circuits
- Data processing
- Visual communications
- Customer premises equipment
- Basic research [70]

CHANGES AT NTT

NTT and the Japanese telecommunications industry are undergoing profound changes to enable them to provide the services that Japan will require in the future.

In terms of operating policies, NTT's procurement system has been opened up to quiet criticism from foreign countries and allow NTT to obtain the best technology available, regardless of source. Free competition will be allowed in areas once monopolized by NTT, because it has become increasingly difficult for a single entity to efficiently provide all the telecommunications services that are demanded.

Technologically, NTT and the Japanese telecommunications industry have embarked on an ambitious plan to totally digitize the Japanese network using optic fibers, satellites and computers, in addition to conventional equipment.

Open Procurement. More than 90 percent of Japanese households have telephones, and NTT, as the owner of virtually all the telephone lines, is the most powerful entity in telecommunications in Japan. Japan has the world's second largest telecommunications equipment market after the U.S., and NTT procurements represent about 40 percent of the total market. [27, 54]

NTT's procurement system had long been closed to companies not within the NTT "family". These closed procurement practices were especially targeted by foreign governments that had large trade deficits with Japan. They were seen as a sign of Japanese unwillingness to open its markets to overseas manufacturers.

Japan, as a signatory government of the Tokyo Round of Multinational Trade Negotiations, agreed to not discriminate in government procurement practices against products or suppliers of other signatory nations. However, NTT had been excluded from the Japanese list of government agencies to be included in the agreement. The U.S. government pressured for NTT's procurements to be opened up and negotiated with Japan for five years before an agreement was finally reached in December 1980. The three-year bilateral agreement between the United States and Japan was formally signed in January 1981. The agreement allows foreign companies to compete for a part of NTT's annual $3 billion procurement market. [3, 22, 48]

To help clarify procedures, NTT held seminars for non-Japanese executives both in Japan and the United States on the new NTT procurement procedure policy resulting from the agreement. It also published many technical texts, guidebooks and newsletters in English for foreign suppliers. NTT announced changes to make bidding even easier for foreign firms in March 1983. Some measures included in the program were:

- acceptance of proposals in English;
- the use of the New York NTT office to accept bids;
- faster response time and larger orders;
- more flexible requirements on some products;
- and introduction of contract terms that conform to international standards. [48]

These conditions were formally included in the renewed Bilateral Agreement signed in early 1984. In addition, the new pact included two provisions to further help American companies sell to NTT. These were:

- procurement opportunities will be announced in the United States
- and American companies will be allowed to submit bids for a period one month longer than Japanese companies. [12]

In mid-1984, NTT also opened a new office in Los Altos, California to make it easier for companies in that area of the country to submit bids. Bids are accepted at offices in London, Geneva, as well as New York and California. [51]

NTT has divided its procurement procedures into three tracts according to the technological sophistication of the items being sought. These are:

> Track I, for the least sophisticated items that are purchased through open bids with suppliers from all countries considered equally. These include standard items such as paper, pencils, and off-the-shelf equipment such as data terminals, facsimile, and PBXs.
>
> Track II items are more sophisticated and have technical and other factors affecting the purchase decision. These are mainline telecommunications equipment available in the marketplace, which can be used as is or modified to meet NTT requirements.
>
> Track III is for items that have not yet been developed and require development for NTT or joint R & D projects between the potential supplier and NTT.

In addition, there are Track II-A and Tract III-A which are for follow-on purchases of products previously procured under Tracks II and III. [64]

Despite some problems and criticism, companies have successfully begun to penetrate the NTT market. Some examples: Motorola was awarded a contract worth approximately $9 million annually to supply portable pagers in November 1981. [30, 47] In March 1983, AT&T sold $2.6 million worth of 2B digital echo cancellers for satellite earth stations and provided the $70 million ATOMICS general telephone management system in 1983. [16, 51]. ITT won a $5 million contract for 400 EP-10 digital PBXs and a $11 million supercomputer was bought from Cray Research. [43, 51].

Open competition in the interconnect market. In addition to the Bilateral Trade Agreement, the Understanding on Customer- Provided Equipment became effective in January 1981. In the agreement, NTT established a mechanism for foreign firms to obtain approval to sell products directly to the Japanese public, which had previously been compelled to buy all telecommunications equipment from NTT.

Interconnect equipment is classified according to the type of connection it uses (leased circuits, subscriber circuits, subsciber circuits of circuit switched/packet switched data networks, etc.) and according to functions included in the equipment (dialing, voice transmission, automatic answering, etc). Procedures for maintaining technical standards have been created, with NTT responsible for final approval of suppliers. Interconnect equipment that might cause interference in NTT's network requires approval; equipment that does not cause interference is under no restriction, but NTT recommends that prior inquire be made before marketing such equipment. [48, 64]

Several companies have won approval of their products to allow them to be sold in the Japanese interconnect market. Examples are Paradyne Corporation for modems, [39] Rolm Corporation for CBXs, Mitel for a digital superswitch, and Northern Telecom for digital PBXs. [16]

Reform of NTT. When Yasuhiro Nakasone became Prime Minister of Japan, he set as one of his major objectives the administrative reform of the government. NTT is one of the prime targets for this reform. A four-step reform plan recommended in 1982 by a special study group (the Second Ad Hoc Committee on Adminstrative Reform or RINCHO) commissioned by the government is one possible way the reform could be carried out.

RINCHO recommended that NTT be changed into a group of semi-private companies over a period of several years. NTT's reform could be carried out in the following four steps:

> Phase I : NTT would be changed to the NTT Company Limited, with capitalization between 500 billion yen and one trillion yen and all stock owned by the government.
>
> Phase II : The new limited company would rationalize its operations. All divisions auxiliary to the main business of providing telecommunications circuits, such as data communications and marketing of equipment, would be separated into independent companies.
>
> Phase III : The remaining divisions would be split into a number of companies. One central company which would manage and operate trunk circuits throughout the nation and several regional companies, each operating and managed independently.
>
> Phase IV : After several years, the Ministry of Finance would gradually sell some of the stock of the central and regional companies to the public. This selloff would supply the deficit-ridden national government with much needed capital. [60]

The three bills designed to reorganize NTT failed to be approved by the Diet in earlier sessions, but they are is expected to pass during the next session in early December 1984 and be enacted in April 1985. According to the new law, the Japanese telecommunications market will be liberalized, but NTT will not be broken up into regional companies for the time being. At first, NTT stock will be entirely held by the government, then up to 49 percent can be sold to the public. While a foreigner or foreign companies will not be able to acquire NTT shares, companies with less than 50 percent foreign interests will be eligible to be stockholders. The bill stipulates "reexamination of the new NTT after five years" to decide if NTT should be broken up into smaller companies. When NTT is transformed next year, it will be capitalized at 1 trillion yen, its assets will exceed 10 trillion yen, and it will have 320,000 employees—clearly the largest company in Japan. [20]

The reforms are necessary to allow NTT to provide adequate services and operate rationally in the future information-oriented society. NTT must increase operating efficiency and worker productivity to cope with the rising costs of operations and decreasing revenues from services. It must have fewer restrictions on its operations. In the age of sophisticated information processing, technological changes will come at an ever increasing pace. Investment decisions and operational changes will require fast, accurate business judgement. Something the present bureaucratic structure does not allow.

The Ministry of International Trade and Industry (MITI) has encouraged the privatization of NTT. MITI realizes that NTT's monopoly is holding up the convergence of computers and telecommunications in Japan. Japanese companies do best in international markets when sales at home are also strong and competitive. If growth of the domestic telecommunications equipment sales is restricted, Japanese electronics firms will be handicapped in competing with foreign firms because they will lack the strength bred by stiff domestic competition. NTT had previously protected some domestic telecommunications equipment manufacturers and allowed them to become established, but now NTT's monopoly probably only tends to weaken the Japanese firms in the international market. [10]

But as with any change, there are opponents to the reform of NTT. Some members of the Ministry of Posts and Telecommunications are opposing the reform, because they do not want the Ministry to relinquish control of NTT. The bills failed to pass the Diet because of strong opposition by the Japan Socialist Party, which was concerned about the fate of NTT's labor union. The 300,000 All-Japan Telecommunications Workers Union is officially resisting the reform, but probably will be willing to cooperate in exchange for a promise of ample job security. Some vocal opposition is also coming from the "Denden Family" members, who profit the most by the present situation. [11, 37] However, in spite of criticism, it is certain that a change must be made.

Increased Competition. The passage of the new telecommunications bill that will change NTT will also allow competitors to provide services in markets currently monopolized by NTT. Many companies have already been formed to study the feasibility of providing long-distance services connecting large business markets—particularly along the 550-kilometer Tokaido corridor between Tokyo and Osaka, where 70 percent of Japan's industries are located. [13].

One consortium is headed by Kyocera Corporation and includes Sony, Ushio Electric, Mitsubishi Corporation, Secom and at least 20 other high-technology manufacturers, trading companies and banks. It will offer audio and data transmission, TV conferences, and mobile and international communications using microwave and optical fiber technology. [6, 13, 16]

Another party considering entry into the telecommunications services market is Keidanren (the Federation of Economic Organizations), which is studying the feasibility of offering services via satellite circuits. Strongly backing the plan is Fujitsu Limited, a Keidanren member and Japan's largest computer maker. [20]

Even other government agencies are studying the possibilities of entering the telecommunications field. The National Railroad, the Japan Highway Public Corporation and regional electric utilities are investigating the use of their land resources for telecommunications. These entities own some kind of bed where optical fibers could be laid, either motorway, railroad track or electric poles. These agencies will probably team up with one of the private companies, rather than trying to provide the services themselves. [7, 20]

Competition in Value-added network services market. The Japanese Cabinet has approved the bill that, when enacted, will open up another field to competition. That field is value-added networks (VANs) using public phone lines. VANs permit users to interact directly from remote terminals with one or more computers and associated data banks, or from one machine to another, regardless of compatibility. The VANs use sophisticated computers and communications technology to carry computer data, electronic mail, and other information among machines of different makes or among machines with different transmission speeds and protocols. [66, 67]

There are two main types of VANs depending on the size of the networks. Large-scale nationwide value-added networks and smaller VANs that are limited to particular geographic areas, industries, companies, groups of companies or computer users.

The new telecommunications bills will allow foreign firms to offer VAN services in Japan. However, the Ministry of Posts and Telecommunications will retain power to screen applications for VAN operations, which could be used as a barrier to the entry of foreign competitors, depending on how that power is wielded.

Because of this uncertainty for foreign companies, many of them have sought Japanese partners to facilitate entry into the Japanese market. Several joint ventures will be ready to enter the market when the bill goes into effect in April 1985. [4] AT&T and Mitsui & Company, IBM and Mitsubishi Corporation, General Electric and Dentsu, GTE's Telenet and Japan's Intec have all agreed to establish firms to vie for a piece of the market. These joint ventures, along with competition from NEC, Fujitsu and Hitachi, which have also announced their entry and NCR Japan and Burroughs, which are considering entry, will make competition for large-scale VAN business very intense. [32, 33, 34]

There are thousands of smaller network services in Japan as well. These link specific industries, companies, or provide specific service functions for users. Among early entrants into the small scale VAN market have been computer service bureaus, transport companies, sogoshosha, and wholesalers.

Information Network System. In the near future, the demand for non-voice telecommunication services will become greater and greater. The amount and variety of data that will be required by homes, offices, and factories will be tremendous. The present telephone system, designed for voice transmission, will not be satisfactory to meet the needs of the future society. To provide for those requirements, NTT has launched a long-term plan to complete a totally digital telephone network based on optical fiber and satellite technology. That system is called the Information Network System (INS).

The main purposes of INS will be:

-digitalization of networks;
-integration of non-voice and regular telephone services into a single network;
-upgrading of the network to allow speed, format, protocol, and media conversions;
-rationalization of the tariff structure;
-promotion of further convergence of computer and communications technologies. [38]

The completion of the total system will take at least until 1995, with different parts being completed gradually in the intervening years. NTT researchers are working to further develop the transmission, digital switching, and customer services that will be essential to INS.

The digitalization of the telephone network began in 1982, with the installation of a full digital trunk switch in Tokyo. Installation of digital local switches began in 1984. NTT is now installing what will be the world's longest lightwave telecommunications link. It will stretch 2800 kilometers from Sapporo to Fukuoka and will be the backbone of the network. Short haul optical fiber systems are already operational in twelve sections nationwide. NTT researchers are among the world's leaders in fiber optic technology. [70] They have also successfully developed state-of-the-art large scale and very large scale integrated circuits to be used in various switching, transmission and customer premises equipment.

Satellite technology is already commercially in use. CS-2, Japan's first domestic communications satellite, was launched successfully February 4, 1983 and went into full use in July. It has six transponders in the K-band and two transponders in the C-band, with 4000 total telephone circuits.

NTT is already using 3000 of those circuits to provide telephone service to remote Japanese islands and the rest for testing. CS-3 will be launched in or around 1987 and an expanded use and a greater range of applications for these satellites is planned. [16]

NTT has expanded both high speed circuit switching and packet switching services to serve most Japanese cities. It also provides various data processing services that allow subscribers to access NTT mainframe computers and perform operations such as scientific calculations and central billing of customers.

Mobile communications services now provided include domestic maritime radio telephone service, telephone service to and from the Shinkansen trains, Pocket Bell portable paging service, and automobile radio telephone service. Automobile radio telephone service was initiated in 1979 and is used by some 22,000 subscribers in Osaka, Tokyo, and Nagoya. Development of a medium capacity land mobile system is underway to allow expansion of service to small and medium size cities. [45]

In addition, a facsimile communication network service was started between Tokyo and Osaka in September, 1981. And the commercial inauguration of the CAPTAIN (Character And Pattern Telephone Access Information Network) occurred in the fall of 1984 with the creation of a company to take over the handling of operations from NTT. Trial service had been carried out by NTT in the Tokyo area since 1979. CAPTAIN is an interactive videotex system that allows economical access of computer-based information services from home or office. It offers data retrieval and other information in characters and graphic form over telephone lines to home or office terminals. [5, 23]

NTT also started operation of an experimental INS system of about 10,000 terminals in the western Tokyo suburbs of Mitaka and Musashino. The test will run through 1986 and will help develop technologies and train personnel in their use. Using the experience gained through operating the pilot project, NTT will install a model system at Tsukuba Science City with service starting in the spring of 1985. Inauguration of this system will coincide with the opening of the International Science and Technology Exposition to be held in Tsukuba. The exposition will provide a showcase for demonstrating the services that will be provided through INS. [27, 44]

OPPORTUNITIES FOR FOREIGN FIRMS

Japan has approximately 60 million telephones in service (second after the U.S.) and accounts for about 12 percent of the total world number. [12] In November 1983, the Communication Industries Association of Japan forecast demand for communications equipment would rise 10.3 percent annually until 1987, when it would amount to 1,901.2 billion yen ($7.75 billion). [36] Similarly, a study commissioned by the U.S. Commerce Department estimated that the total telecommunications equipment market in Japan will amount to over $6 billion dollars in 1986, an increase of 63 percent over 1980. Telephone and telex equipment sales are forecast to grow to $2.8 billion, and transmission equipment sales will total $2.4 billion, up 62 percent and 48 percent, respectively over 1980. Domestic production will satisfy most of the demand, with imports possible in some areas. Imports are forecast to total $204 million, or three percent of total domestic sales. (see table 1) [63]

Because of the forecasted high growth in demand and the many changes in NTT and the telecommunications industry in Japan, there are several possible opportunities in that country for foreign firms. These are:

-NTT Procurement;

-Interconnect Market;

-New phone companies purchases;

-Providing Value-added network service.

NTT Procurement. In fiscal year 1983, NTT's purchases of telecommunications equipment from foreign manufacturers totaled 34.8 billion yen ($140 million). This brought the total of NTT's purchases from foreign firms to 50.2 billion yen in the three years since the new procurement policies were implemented. [43, 51]

From January 1981 to June 1984, NTT issued requests for proposals under Track II procedures and issued invitations to participate under Track III for 53 products. NTT selected 41 products from 88 firms. However, the number of applications from foreign firms has been relatively low. NTT acted on applications for 13 products from foreign companies and eventually selected only six products from six foreign companies. [51]

NTT is in the process of revamping its entire network and requires much equipment that has yet to be developed. There are many opportunities for foreign firms to help develop these technologies. Between April 1983 and July 1984, NTT requested assistance to produce 32 items under Track III procedures, which is probably only the beginning of the items that will have to be developed to complete the INS. American firms should make stronger efforts to participate in NTT's R & D projects. The firms that participate would have much of the R & D costs covered, they would receive lucrative contracts for the items developed, and they would be in the forefront of technological developments in Japan.

Interconnect market. Sales in the interconnect or consumer-provided market in Japan are growing rapidly and will soon be greater than NTT's own procurement volume. From fiscal year 1981 to FY 1983, the market for consumer-provided equipment grew by 44 percent compared to a growth rate of only nine percent for NTT's procurements. In 1983, the interconnect market totaled 450 billion yen ($1.8 billion) compared to NTT procurements of 490 billion yen ($2 billion). NTT's share of the interconnect market has now shruck to less than 1/3, with the majority of equipment currently provided by private concerns. [49, 51, 68] With the expansion of the digital network and increased availability of more sophisticated equipment, the demand for customer-provided equipment will continue to increase rapidly. Furthermore, the synergism resulting from the convergence of computers and telecommunications will create opportunities and market demand that are impossible to predict.

New Phone Companies. The new common carriers that may be formed will require enormous capital investments for equipment, land, labor and other expenses. Before they can start to provide service, it is estimated that the fiber optic method will cost between 30 and 50 billion yen (about $120 to $200 million), while 20 billion yen ($80 million) would be required for the method using a satellite. [13, 20]

Much of this equipment will probably be supplied by the firms that participate in the new ventures. However, in the new highly-competitive environment, the companies that provide comparable services at the lowest cost will be the most successful. Therefore, when installing their facilities, the newly-formed companies will have to act rationally and purchase the best equipment they can for the lowest price. For example, the new phone companies are especially interested in using foreign-made communications satellites, which would have much greater capacity and operating efficiency than NTT-developed ones. Likewise, NTT in this new competitive situation must begin to emphasize value in its purchasing rather than be overly influenced by long-standing supply relationships. The competitive environment will provide many opportunites for companies that can provide the equipment with the greatest value.

VAN Markets. Because of the large initial capital outlay necessary, the establishment of large-scale VANs is limited to giants like AT&T and IBM. Consortiums may be formed to provide these services as well, but participation will be more logical for the users rather than foreign companies not receiving the services. Possible opportunities will exist for foreign companies to provide more specialized services, such as credit card checking, on-line banking services, electronic mail networks and information services, ticketing services, and security services for homes and offices. Many American companies that have experience providing these services in the U.S. could utilize their expertise and provide the same services in Japan.

INS. The establishment of a totally digital network is a very expensive proposition because the entire network must be overhauled. The capital required over the next decade for the construction of INS in Japan is around 30 trillion yen ($122 billion). [36] Successful development and construction of INS will require many technological innovations and the production of functional equipment. Those companies, whether Japanese or foreign, that can provide the necessary equipment will win the contracts to supply NTT and sell to the businesses, industry and the Japanese people. This is an opportunity for American firms that have traditionally been innovative and able to lead the world in technological advances.

Steps have been taken to alleviate the chronic Japanese weakness in system software development. This is evidenced by NTT's planned software lab and MITI's proposed project to mechanize software development. In the meantime, some Americans could possibly profit by helping the Japanese in software development.

CONCLUSION

To successfully enter any foreign market is not easy. It is a lengthy process that requires careful examination of the potential market and of the firm's own resources as well. The same is true for the Japanese telecommunications market. In a U.S. General Accounting Office report, major industry officials were quoted as saying "successfully penetrating a major foreign telecommunications market generally takes at least three years. The supplier needs time to study the new telecommunications system and to learn how to deal with the new customer... The customer needs time to assess the supplier and its products."[64]

The first step the company must take is to decide if there are enough potential returns to warrant the investment necessary to succeed in the Japanese market. The opportunities are many, as detailed in this paper. Japan is an attractive market in itself. It is the second largest economy in the world and is one of the more rapidly growing. It has a superb infrastructure; stable political environment; stable, well-educated labor force; and an affluent populace that readily accepts change. Now is an opportune time to enter the Japanese telecommunications market because it is currently undergoing such major changes. The highly competitive environment will force NTT and the new service providers to procure the best equipment with less consideration of traditional relationships.

Although the blame for the relative inability of foreign companies to compete successfully in Japan is often attributed to nontariff trade barriers erected by the Japanese, it is often the foreign companies themselves that are responsible for their own lack of success. Many American companies are not sufficiently export-oriented. They are often unwilling to learn about Japan and the Japanese market and do not do what is necessary to establish a position there.

If the decision to compete in the Japanese market is made, the company must be willing to adapt its products where necessary. It must be patient and willing to forego profits in the short-term in order to reap long-term benefits. It must be willing to invest enough capital into personnel and facilities in Japan to succeed. The personnel must be versed in the intricacies of the Japanese market and be willing to establish the necessary rapport with the proper officials and companies. They must be able to speak Japanese, which many foreigners dismiss as "unlearnable" by gaijin (if more than 100 million people are able to learn the language then it is certainly not impossible). The opportunities are there in Japan. It is up to the foreign firms to seek them out.

Table 1. TELECOMMUNICATION EQUIPMENT SALES 1980 and 1986 AND IMPORT REQUIREMENTS

(in $$ millions)

	1980	1986 (projected)
TELEPHONE AND TELEX EQUIPMENT		
switches and switching equipment ...	599.1	640
subscriber/user premises equipment .	1,030.8	2,030
other telephone and central office equipment..................	100.0	175
telex equipment.....................	36.5	45
Total market................	1,766.4	2,890
domestic production.................	2,120.4	4,228
imports.............................	7.2	21
exports.............................	(361.2)	(1,359)
Total market................	1,766.4	2,890
TRANSMISSION EQUIPMENT		
wire and cable......................	734.4	712
high-frequency radio................	165.1	302
microwave...........................	254	470
lightwave...........................	14	307
multiplexers........................	104.8	247
other carrier devices...............	342.3	353
Total market................	1,614.6	2,391
domestic production.................	1,980.9	2,980
imports.............................	22.7	100
exports.............................	(389.0)	(689)
Total market................	1,614.6	2,391
MOBILE RADIO		
conventional mobile radio...........	161.8	325
mobile telephones...................	18.6	140
paging systems......................	48.1	56
marine..............................	40.7	65
air-ground communications...........	1.3	4
Total market................	270.5	590
domestic production.................	362.7	690
imports.............................	-----	58
exports.............................	(92.2)	(158)
Total market................	270.5	590
DATA COMMUNICATIONS EQUIPMENT		
modems..............................	111.9	280
acoustic couplers...................	1	2
network control units...............	1.2	3
other...............................	9.3	31
Total market................	123.4	244
domestic production.................	124.8	247
imports.............................	12.4	25
exports.............................	(13.8)	(28)
Total market................	123.4	244
TOTAL FOR ALL CATEGORIES	3774.9	6,115

Source: U.S. Dept. of Commerce, International Trade Administration. Telecommunications Equipment: Japan, April 1983.

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ALASKA/PACIFIC RIM ECONOMIC RELATIONS
and the Potential Role of Telecommunications

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ABSTRACT

Given the circumstances — Asian countries that must import resources to support their industries and Alaska which seeks to diversify its oil-based economy, it is certain that efforts will be expanded to encourage trade in the Pacific Rim. This article surveys the four major state economic activities: oil and gas, mining, forestry, fisheries, and examines the need for information and telecommunications systems that will support these development efforts. A central argument is that an expanded telecommunications system is needed to coordinate information processing and analysis of trade and economic patterns in the Pacific Rim. Our objective is to stimulate discussion of the role telecommunications can play and its importance.

INTRODUCTION

While it is evident that Alaska will begin diversifying its economy by increasing trade with Pacific Rim countries, it is doubtful that economic policies alone will be sufficient. The major reason for this relates to Alaska's location and unique social and physical characteristics, as well as the role that Alaska's resources play in the overall scheme of resource trade. Heretofore, the state policy focus has been only on the supply side of the market, but making a resource available for export does not insure its sale. Ignorance of the complex factors important to understanding markets puts businesses at a great disadvantage. Realistic expectations are based upon appreciation of major considerations. A lack of information inhibits the ability to make careful and broad plans, and puts Alaskans at a disadvantage in negotiating trade agreements.

Alaska's involvement in the Pacific raises many interesting questions. The purpose of this article is to stimulate discussion about the needed institutional arrangement conducive to diversification of the Alaskan economy. This article is divided into two sections. Section one presents a brief survey of the principal Alaskan economic activities: oil and gas, mining, forestry, and fisheries. This overview presents an analysis of past developments and future potential. The second section discusses the important role to be played by telecommunications and a framework for considering that role.

SECTION ONE

OIL and GAS Estimates place the amount of recoverable Prudhoe Bay oil at about 9.6 billion barrels and about 26 trillion cubic feet of natural gas. Other estimates run as high as 20.2 bbs and 44.9 tcf of natural gas (about 25% of the known petroleum reserves in the United States). Of the 1983 daily Prudhoe Bay productionof 1.5 mbs, about 900,000 went to U.S. West Coast refineries, 500,000 to the Gulf Coast via the Panama Canal, and about 100,000 went to the East Coast. An additional 100,000 barrels per day is produced in the Cook Inlet region. Of the numerous petroleum and natural gas resource deposits in Alaska, only these two fields have been brought into production. The U.S.G.S. estimates that approximately 44% (between 10.9 and 36.4 bbs) of the total U.S. recoverable supply of off-shore oil, and that 39% (between 16.5 and 55.5 tcf) of the total U.S. supply of natural gas lie in the Alaska Outer Continental Shelf. Of the 12 OCS tracts only a few have been explored so far. Because Prudhoe Bay is state land, the state government collects a 12.5% royalty (about 188,000 barrels per day or 69 mbs per year). It is estimated that oil accounts for up to 83% of all state revenues and indirectly is responsible for up to 50% of all jobs.

The Mineral Leasing Act as amended by the Trans-Alaska Pipeline Act, prohibits the export of oil carried by pipelines over federal rights-of-way. Efforts aimed at getting Congress to change this law have failed, despite the substantial benefits that would accrue. One alternative that complies with this law would transport Alaskan oil to Hawaii for refining and export.

Only small amounts of Alaska natural gas reserves have been developed; some from the Kenai Peninsula is exported in a liquified form. Two proposals have been made for the construction of a natural gas pipeline transportation system. One that received federal approval, but was tabled due to higher than anticipated costs and other large natural gas finds, called for the construction of a pipeline through Canada branching off in two routes to the Midwest and

California. Another proposal calls for the construction of an in-state line roughly paralleling the TAPs line from Prudhoe Bay to Valdez. Both are still being considered. It is not yet possible to determine which of the two plans may be implemented.

MINING Alaska is capable of producing a variety of minerals for export. In addition to gold, other principal minerals are antimony, coal, lead, limestone, mercury, silver, tin, tungsten and uranium. In 1983 Alaska's mineral production was $232 million, an increase of 18% over the 1982 level. Since 1981, total exploration expenditures for Alaska have declined by more than 44%. A variety of factors including depressed metals prices has discouraged firms, but the potential exists for several major mining operations, given the high grade ore concentrations which offset development costs. Technological and capital requirements necessitate the involvement of multinationals.

Another consideration important to the mining industry is the lack of a transportation infrastructure. Within the 586,000 square miles in Alaska, there are less than 10,000 miles of roads, and only about one-fourth are paved. Southeastern Alaska does have access to marine transportation, and for that reason the Green's Creek and Quartz Hill mining projects in that region have a strong chance. Another possibility is the Red Dog, a zinc, lead and silver mining project in the Kotzebue area. In a joint venture with NANA Regional Corporation, Cominco of Canada plans to open a mine 55 miles from the Chukchi Sea. This $400 million project is based on estimated ore deposits of 85 million tons — with an average grade of 17% zinc, 5% lead, and 2.4 ounces of silver per ton. Since Cominco is one of the largest mining and smelting operations with established markets it is probable that this venture will be realized.

Alaska coal resources are enormous. A 1979 Department of the Interior estimate indicates the potential Alaskan coal resources exceed the top six coal producing states. The state government's estimate ranges from 168 billion tons of identified reserves to 5.6 trillion tons of potential undiscovered resources. Alaskan coal is abundant and relatively low in sulphur. Since 1970 the only commercial coal mining operation has been the Usibelli Mine located in the Interior. Current production from this mine is about 803,000 tons — a 14.7% increase from the 1980 level. The Healy field and another located in Southcentral, the Susitna, are the two coal producing areas in the state that are considered to have the greatest near term development potential. In 1983 a 15-year contract was signed with Sun Bel Corporation of South Korea providing for annual export that could double current production from the Usibelli Mine by 1987. The Susitna could begin commercial production if market conditions become favorable.

FORESTRY Alaska's forestry industry is concentrated in the Southeast, although prospects are good for the Interior. The Tongass National Forest (TNF) covers about 17 million acres with 7 million of those acres designated for commercial use. Under Section 705 of ANILCA, the Forest Service is required to make 4.5 billion board feet available to the timber industry per decade. Commercial timber is also harvested from the 550,000 acres of land that Alaska Natives received under their land claims. Since Alaska Native corporations cut timber on lands that are exempt from federal regulations that prohibit round log exports to foreign markets, they maintain a strong position with the Japanese who prefer to process the timber in their own country. Although Native production is also anticipated to fluctuate in response to market cycles, it is estimated that long-term sustained yields could range up to 225 mbf per year.

Alaska's timber industry competes in the markets of the Pacific Rim. The strong connection between Southeast timber and the Japanese economy make timber sales subject to fluctuations. Forest products contribute the second largest share of total Alaska exports by dollar volume. In 1983 $268 million of forestry products were exported. Of this amount, over $201 million went to Japan in the form of cants, round logs, pulp and chips. In contrast to other major producers, Alaska's forestry exports are small. In the state, however, the timber industry is a major activity directly responsible for about 2,900 jobs.

The current industry structure can be traced to past Forest Service policies which offered long-term (50 year) contracts and other incentives to firms agreeing to build processing mills in Southeast Alaska. Of the 474.4 mbf of timber made available from the TNF, 277.1 mbf or 58% went to two companies on the basis of long-term contracts. Because of the variations in both composition and quality of forests in Southeast, the Forest Service has chosen to offer additional incentives in the form of subsidies for road construction and mixed offering favoring higher quality timber in order to secure the mandated sales. Yet, even with these additional incentives incentives the amount of timber harvested from the TNF has fallen steadily since 1979 from 422.1 to 250.4 mbf in 1983. It is premature to make any determination of what changes in the market are likely to occur. One observation is that in the past, Alaska resources, especially timber, were developed without capturing the important economic linkages.

FISHING The fishing industry in Alaska has evolved to become one of the most economically significant. Salmon fishing and processing have been the most important components of the industry. In 1980 the Alaska contribution has made up about 45% of the world's Pacific salmon harvest.

Other important fisheries include: crab, halibut, herring, and shrimp. Bottomfish such as pollock, cod, ocean pearch, sablefish, and rockfish offer great economic potential. Most of the resources harvested in Alaska waters are caught and processed by foreign vessels.

The Fishery Conservation and Management Act (FCMA) established a 3 to 200 nautical mile zone. (For Alaska, an area roughly equal to 2.2 million square miles). Under this act U.S. fishermen/processors receive preferential treatment but, due to limited involvement by domestic firms, foreign nationals have been permitted to take considerable amounts of the fish. In the past, the largest allocations have gone to Japan, the Soviet Union, and Korea. The technology and experience in harvesting and processing other species has existed for a number of years in other countries. It is obvious that the Alaska fishing industry could benefit from countries which have incorporated modern innovations such as commercial hatchery operations and bottomfishing.

This brief overview highlights the enormous potential of Alaska natural resource development. Yet, even though abundant opportunities exist to establish new businesses or expand existing ones through trade with Pacific Rim countries, these economic activities will be successful only so far as there is an up to date information base to help coordinate investment and trade policy. Section Two discusses the development of telecommunications in Alaska, and examines the important role communications and other information technologies can play in facilitating the state's efforts in trade promotion.

SECTION TWO

Telecommunications and Information Technologies can serve major roles in support of the marketing of Alaskan resources within the Pacific region. They can serve to facilitate the following:

- Improved understanding of resource markets;
- Appreciation of industrial sector requirements in the Pacific;
- Knowledge of various cultures and business practices as a requisite to mutually productive economic ties;
- Enhanced technological and cultural exchanges
- Improved economic performance (stability).

For example, in order to participate effectively in Pacific trade, the Alaska timber and fishing industries need more information about Asian consumer markets. This information includes such specifics as current and projected resource needs in Pacific Rim countries, specific requirements for resources, alternative sources of supply, and so on. The mining industry needs more information on industrial sector requirements in specific areas such as financing, transportation, and unique handling and processing requirements. To effectively conduct business with Pacific trading partners, Alaska Native Corporations require information on the cultures and languages of these countries and the common business practices of these countries, particularly where they differ from familiar American practices.

To facilitate effective participation in Pacific trade, Alaskans need to participate in enhanced technological and cultural exchanges. Because of the geographical location of Alaska and its isolation from the mainstream of even the U.S. economy Alaskans have not often engaged in these types of exchanges in the past. The exchanges are needed both for familiarization with techniques and context of Pacific trading countries, and also for the establishment of economic contacts which could serve to facilitate specific instances of trade. Moreover, Alaskans require information that will help to improve the economic performance of major industries. The timber industry, for example, has long been subject to pronounced cycles. While the exercise of control over these factors is doubtful, their prediction is often possible. Armed with predictive knowledge the state may be able to adjust or refocus its efforts in order to minimize the impact of downswings and take advantage of new growth opportunities.

Telecommunications Development in Alaska

As recently as a decade ago communications were spotty at best in the rural areas and limited in urban areas. In the past ten years the state of Alaska in cooperation with the long-lines carrier in the state, Alascom, has undertaken major developments in the communication area. The goal has been to provide the full range of communications services: telephone, video, data, etc., to all communities in the state. The solution has involved putting in place a sophisticated satellite-based system involving both space and ground segments. Today a large offering of services is available even in most remote communities. These services can provide assistance of many types to entrepreneurs and resource extractors in the most distant reaches of the state.

These efforts have made available a remarkable cluster of services including the installation of an electronic mail, data base systems, and the development of a statewide educational audio and video network dubbed LearnAlaska. Concurrently, schools in the state have begun to make extensive use of stand-alone microcomputers for classroom instruction and school administration. These systems serve both to provide services and to raise the general skill levels of both staff and students in applying sophisticated electronic technologies to modern-day problems. Systems that are now in place can serve as integral parts in implementing some of the recommendations of this paper, and as models for systems that could be developed to more directly support economic and resource development in the state.

Telecommunications: Actuality and Potential

Presently, only certain pieces of these types of information are gathered through both public and private sector efforts. Some research data are gathered through traditional processes (e.g., scanning published reports, contracting for research studies, and producing written reports); however, the data tend to be narrowly focused and often dated. Limited exchange visits are undertaken by government and business leaders, but only a few select individuals participate in the exchange. Consequently, opportunities for follow-up and broader participation are limited. While these activities are certainly useful, a much broader approach to the problem is needed. Yet in the short run, accelerated data gathering, dissemination, and participation in exchanges is neither practical nor likely.

In order to solve the problem, modern electronic technologies appear to offer great potential. For example, in assessing and providing access to current and future resource markets and Pacific Rim industrial sector requirements, computerized data bases and data communications components are needed. With one or two exceptions, such as the information services provided by the U.S. Department of Commerce, International Trade Administration, there is little aggregated or detailed information available to the potential entrepreneur. In the case of the Alaska Office for U.S.D.C., the information is in microfiche and printed form and is not easily disseminated nor structured for distant-point utilization. While multinational corporations operating in the state may have access to such data bases these are neither shared with other elements in the private sector nor with educational institutions or state government. The greater availability of relevant data bases appears to offer potential to both sectors to engage in the short term and strategic planning required to sustain long-term economic development.

The acquisition of knowledge of Pacific Rim cultures and business practices can be facilitated by technology as well. Plans are now on the drawing board for a multi-faceted approach to the educational requirements for Alaska's citizens in this regard. The plans call for the development of curriculum materials to promote a better understanding of our Pacific Rim neighbors. They also call for an increased emphasis on Asian language instruction.

In implementing the curriculum, telecommunications has been targeted to facilitate several components of this program, both within and without the state. Within the state the telecommunications systems in place will be used both for the training of teachers and the delivery of instructional activities for students. Telecommunications can also serve to link educators and students to their counterparts in other Pacific Rim countries to facilitate discussion and interchange of ideas. In planning for these services the needs of both public school and post-secondary students are being considered.

At the same time, similar planning needs to be being undertaken regarding the needs of the private sector for information, training and exchanges. In a similar way telecommunications has the potential to play an important role in this sector.

A Conceptual Framework for Using Telecommunications Technology to Address Information Needs for Alaska

In order to build a constructive climate for economic development in Alaska, particularly as that development relates to Pacific Rim trade, the needs of a broad spectrum of Alaska's citizens must be considered. While it is sometimes tempting to view Pacific trade as the realm of economists and business leaders, it is imperative that efforts to support this development not be narrowly focused upon a small minority of citizens. Experience would indicate that successful and significant economic relations must be preceded by cross-cultural appreciation and interpersonal understandings. From an educational standpoint this is a much broader task than that involved in the provision of technical data related to the economic geography of the Pacific. It is proposed here that the following four sectors be integrally involved in these efforts: the business community; the government sector; universities; and schools. It is further proposed that the interrelationships among these entities be considered as well as their unique roles. The overall result of such efforts should enable all Alaskans to be well prepared to participate in economic development to the fullest possible extent.

Building such a climate through the interrelated involvement of these groups will not be easy. The precedents for cooperation among these groups on an undertaking of this scope are few; however, Governor Sheffield has established a Governor's Interagency Committee on Education for International Trade and Resource Management to foster educational contributions on Alaska and its relationship to the Pacific Region. The stage is set for just such a cooperative effort which includes providing an interagency forum for the exchange of information and joint planning; increasing educator and student understanding of economics, resource use and management, and governmental policies impacting the

Alaska economy; contributing to the long-term development of a stable economic base for the state through increasing the capability of Alaskans to participate in international markets, and increasing the knowledge of Alaskans about the state's resources and the management of those resources; and improving the level and quality of international relations among Alaskan groups and governmental entities found in the Pacific.

What is needed in the long run is the development of an entity to coordinate the activities of the respective sectors and facilitate the overall effort. This entity could take the form of a commission or non-profit corporation. It needs to consider the roles each sector can play, the interrelationships among them and the resources and infrastructure necessary to bring about the desired result.

The following considers some of the important roles that each of the sectors might play.

1. Business Community: Resource development planning should be based upon current and projected resource demand; methods for resource extraction, management, harvesting, and preprocessing consistent with the needs and requirements of industry in Pacific Rim countries; identification and evaluation of opportunities for trade; negotiating specific agreements; fulfilling operations, maintenance, and delivery requirements.

2. Government Sector: Planning for overall resource development based upon current and projected resource demand; facilitating the acquisition and dissemination of vital information; facilitating and/or sponsoring research into extraction, management, harvesting, and processing technologies; planning and facilitating the overall education and training programs needed to assure the preparedness of the state's citizens involvement in economic development; facilitating and participating in exchanges of various types with Pacific Rim countries; cultivating favorable relationships and agreements with Pacific Rim countries which foster positive, long-term economic and political ties; and coordinating the state's activities and policies with federal policies and initiatives.

3. Universities: Gathering, analyzing, and disseminating data vital to economic development in the state; proposing short and long-term strategies and policies for economic development; conducting research in areas such as resource extraction technologies, economic development models, methods of trade, training and education requirements and methods, etc.; providing specific job-related training to Alaskans participating in or seeking to participate in Alaska's economy; providing education at both introductory and advanced levels on topics related to economic development, foreign trade, and Asian languages; and participating in cooperative exchanges with academic institutions in Pacific Rim countries.

4. Schools: Providing general information to all students on Alaska resource development and its relationship to Pacific Rim trade; provide information to all students on Pacific Rim countries, their cultures, resource markets, and methods of conducting business; provide Asian language instructions to teachers and interested students; participate in exchanges with representatives and schools in Pacific Rim countries; provide the basis for further education and training in areas related to economic development and/or trade on the part of students.

Based upon the multiple activities for each sector, the possible interrelationships among sectors are too numerous to list in full in this paper; however, some factors are summarized below.

1. Improved understanding of resource markets

There is a need to share and build upon the data already in existence, to create coherent, accessible data bases, and to establish methods of searching and summarizing data. To understand resource markets one must have access to data organized in a convenient, accessible form. Government, industry and universities must have access to relevant portions of the required data. Schools and universities have roles to play in providing instruction both in the data themselves and methods of obtaining, interpreting, and analyzing the data. Government and business need to act on the data based upon a common understanding of the results and projections and so on.

2. Appreciation of industrial sector requirements in the Pacific

The sectors most likely to have access to information on resource requirements for Newly Industrialized Countries are business, government, and universities. Where it is unavailable, data may be gathered by any one of these sectors, but it needs to be made available to all sectors. Government and universities would likely share the roles of education and information dissemination to the business community and the public.

3. Knowledge of various cultures and business patterns

Universities and the business community would have most direct access to this information. Government would facilitate the acquisition of this information and its dissemination. Schools and universities would serve to provide training and education in this area. Business would utilize the information for planning, development, training and operational methods. Such efforts would help prepare Alaskans to effectively conduct business in different cultural environments.

4. Technological and cultural exchanges

Government participation would emphasize facilitating the technical climate for exchange and trade, as well as addressing international policy issues. University exchanges would emphasize technology, information exchanges, and the studies of trade development. Business exchanges would focus upon specific trade agreements, processing technologies, and joint venture arrangements. School exchanges would focus upon general cultural and language concerns. Thus the form of the interrelationships among the sectors varies depending upon the type of area considered. All of these exchanges require coordination and information transfer among sectors. Planning for information systems and telecommunications would need to take the unique and interrelated requirements of the various sectors into account.

The point of this discussion is to demonstrate that coordinated economic development involves all four sectors, that each has a unique role to play, and, yet, that these roles are interrelated. More specifically, in planning for communications and information processing functions related to development initiatives it is of value to specify the roles of these sectors and the interrelationships amongst them. In this way systems design can be optimized and roles and responsibilities defined that lead to appropriate involvement of the sectors as well as the integrated functioning of the overall system. Both internal and external linkages need to be considered in the planning.

What remains in the specific planning of communications and information processing systems once these linkages are defined is the selection of appropriate systems for particular functions that take into account these linkages. The systems can be as simple as the exchange of videotapes among schools in different countries or may take the form of sophisticated communication networks and computerized data bases. Some of these systems are under consideration in Alaska, others are yet to be considered. We fervently believe that their systematic development can assist in economic development in the state, and we hope to be able to provide an update on this development at some point in the future.

SUMMARY

In some respects Alaska is similar to a Third World country. The state's economy is currently linked to oil but it is necessary to carry diversification through trade as far as possible. Opportunities for such diversification are strongest in industries for which there already exists export markets. Alaska is in an excellent position to evaluate its prospects and plan state participation. Such a diversification strategy should strike a balance between the cost of development subsidies and the benefits to be realized through these investments. In order to be successful this effort will require an expanded telecommunications system and information technologies.

An Overview of High Speed Digital Service in the United States

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1. Abstract

The divestiture of AT&T, the FCC actions to deregulate customer premises equipment, and the changes in technology have caused changes in the services offered to customers by the telephone companies. New interfaces and services are now available. IBM is finding that customers with distributed data applications have demands for faster and more economical data circuits. The availability of the ACCUNET (a Service Mark of AT&T) T1.5 1.544 Mbit/s service by AT&T is very attractive. This paper discusses a technical overview of this service.

Note: As this paper was being written, tariffs for high speed service were evolving which could cause concern for data users.

2. HISTORY

In 1962 the first digital carrier system was introduced into the U.S. telephone plant as an alternative to metallic interoffice trunks. On this system, 24 voice signals are amplitude sampled, digitally encoded, and time shared; each direction of transmission is on a single pair of copper wires. This results in a 12:1 improvement in efficiency in the use of copper pairs as compared with the two-wire metallic trunks. The first-generation channel bank is designated the D1 bank, the D1 standing for Digital, first generation. The D1 bank performs the time-shared sampling and digital encoding of the 24 voice signals into a 1.544 million pulse per second signal.

Since 1962 three additional generations of digital banks have been developed. The first three generations, D1, D2, and D3, offered a relatively modest set of features. For example, toll quality (64 Kbit/s Mu-Law Digitized Voice) transmission started with D2. (It was also offered later on an optional basis for D1 as the D1D bank.) The present generation is designated the D4 bank and was introduced into the field at the end of 1976.

By the end of 1980, the Bell Operating Companies (BOCs) had installed approximately ten million digital channel banks consisting of D1, D2, D3, and D4 families. The concept of offering a wide variety of capabilities on an optional basis came through the basic D4 architecture. It began a new era characterized by expansion of applications through integrating interfaces with other parts of the network. The result is a ubiquitous, flexible, and cost-effective realization of capabilities, which would not have been achieved by separate pieces of equipment. (Reference 1.)

The D4 bank is designed with a capacity of 48 channels (the previous generation banks interfaced only 24-channel systems) with optional multiplex plug-ins to deliver either two DS-1 signals to two T1 24-channel lines, or one DS-1C signal to a T1C 48-channel line. [DS-1 is a 1.544 Mbit/s bit stream containing 24 pulse code modulation (PCM) coded channels, and DS-1C is a 3.152-Mbit/s bit stream containing 48 PCM coded channels.] By interconnecting two D4 banks and by employing another set of multiplex plug-ins, a DS-2 signal is generated for transmission over the T2 96-channel system. (DS-2 is a 6.312 Mbit/s bit stream containing 96 PCM coded channels.) If yet another set of plug-ins containing lightwave transmitters and receivers is used, a signal at the DS-2 information rate is generated for transmission over fiber. The concept of generating various digital signal rates by employing optional plug-ins in the bank results in significant economies as compared with providing the multiplex function with segregated equipment in a separate bay lineup in the central office. (Reference 1.)

The D4 family has grown to include the following broad capabilities:

1. Integrated interfaces for the digital line facilities, with interconnection capability for T1, T1C (two options), T2, and lightguide, using a set of D4 common plug-ins.
2. Integrated interfaces to metallic facilities for the provisioning of special access and private line arrangements by a set of D4 plug-ins called special service channel units.
3. Direct access for the Digital Data System for the Dataphone Digital Service (DDS) by a set of plug-ins called "Dataports." (Reference 2.)
4. Integrated interfaces for the No. 1, 2, and 3 ESS (Electronic Switching Systems) trunks through channel unit plug-ins. (Reference 2.)
5. A D4-technology-based subscriber digital carrier system, SLC-96, designed for "feeder" cable relief in loop applications.

The first three integrated interfaces for the digital line facilities were available with the initial D4 offering in 1976. The T2 and the lightguide interfaces were offered in 1979. Dataports were introduced into service in late 1978, and the SLC-96 system in the Spring of 1979. (Reference 1.)

2.1 PHYSICAL EVOLUTION

When DDS was first offered in the mid 1970s, the customer loop to the Serving Central Office (SCO) was terminated in an Office Channel Unit (OCU), which was multiplexed to the T1 line speeds, and the connection was routed through the network as a separate T1 link or transmission path. DDS was a separate data service using previously unused bandwidth under the voice channels [called Data Under Voice (DUV)] of the microwave transmission system and not integrated with the voice network.

However, two factors are now causing change. They are:

1. An FCC decision in October 1983 separated all CPE, including the DDS-CSU device, from the service. AT&T Communications issued a new preliminary technical reference that described the interface requirements. (Reference 4.)

2. The old DDS (DUV) technology is becoming overcrowded. In 1985 only the "mixed" network, where Data and Voice are assigned channels in the network, will exist. As attaching devices migrate in design to the new service, they must adhere to the new network requirements.

Beginning in 1985 only the framed formatted network interfaces will be offered. The digital connection through the network will be intermixed with other T1 voice and data connections without special routing.

2.2 NETWORK INTERFACE

The June 1983 FCC decision on Docket 81-216 separated customer premises equipment from the basic communication service. The carriers then filed new tariffs and published new technical references that describe the interface requirements. These documents are listed as References 3. and 4. at the end of this paper. Both documents are preliminary and incomplete, calling for unnecessary interface requirements. Both publications are being reviewed by AT&T Communications and each BCC. The publications will be either rewritten or republished under different numbers. Until such time as these are explicit interfaces, the equipment designer must decide what functions he will provide and negotiate with either the BOC or AT&T Communications for that interface. To further assist in defining these interfaces, a new standards committee under the American National Standards Institute (ANSI) has started to develop this T1 interface. This new group is the Exchange Carriers Standards Association (ECSA - T1C1.2 Committee). An approved standard is not expected before Fall of 1985.

2.2 CHARACTERISTICS OF THE PROPOSED CUSTOMER EQUIPMENT TO NETWORK INTERFACE

2.3.1 PHYSICAL INTERFACE

- CONNECTOR - 15 PIN (ISO 4903) 10 PINS ASSIGNED
- LINE BUILD OUT (LBO) - 7.5 DB TO 35.5 DB AT 772 KHZ
- IMPEDANCE MATCHING - CUSTOMER RESPONSIBLE
- TECHNOLOGY - TRANSFORMER COUPLING CIRCUITS TO METALLIC CABLE (NON-LOADED STAGGERED - TWISTED AND PAIRED)

  TWO TYPES OF CABLES ARE USED

  - 0.073 TO 0.083 uf/mi AND 100 OHMS AT 772 KHZ
  - 0.066 TO 0.072 uf/mi AND 120 OHMS AT 772 KHZ
- LONGITUDINAL BALANCE - 35 DB FROM 50 KHZ TO 1.5 MHZ

The impedance matching procedures described in Reference 3. create two problems for the designer:

1. The impedance should be defined in two parts: telephone company side and customer side giving the designer more realistic design limits.

2. The parameters of the loss, if expressed in dB, should be stated in dB of return loss and should define the measurement technique to obtain these parameters.

2.3.2 SIGNALING RATE

- T1 TYPE BIPOLAR AT DS1 RATE OF 1.544 mbit/s +/- 75 bit/s
- 193 BITS IN 125 MICROSECOND FRAMES

2.3.3 PULSE DENSITY AND CHARACTERISTICS

- NO MORE THAN 15 CONSECUTIVE BINARY ZERO'S WITHOUT A BINARY ONE
- PULSE CHARACTERISTICS
  - BIPOLAR + OR - 3 volts +/- 0.3 volts
  - ON - 324 nsec +/- 45 nsec
  - OFF - 648 nsec +/- 15 nsec
  - RISE OR FALL TIME - 100 nsec
  - ALLOWED OVERSHOOT - 10% TO 30%

- TIMING JITTER
  - OUTPUT NOT TO EXCEED 0.07 UNIT INTERVALS
  - INPUT (NOT SPECIFIED)

The pulse characteristics expressed here are those of the interface at the output of the in-line T1 amplifiers. The mid-span connecting point (e.g., customer) Network Interface (NI) may require different pulse characteristics defined in terms of the dB of return loss of Paragraph 2.4.1. This could be a problem for the designer.

2.3.4 POWERING

- INTERFACE MUST BE 60 ma CONSTANT CURRENT LOAD
- CRITICAL CIRCUITS POWERED FROM TELCO (6 DIFFERENT VOLTAGE COMBINATIONS)
- OTHER CIRCUIT POWERING PROVIDED BY CUSTOMER

An interface that requires six (6) different voltage combinations creates an unnecessary problem for a designer.

2.3.5 SIGNAL FORMAT

- 5 TYPES DESCRIBED (ONLY ONE AVAILABLE TODAY)
  - D4 FORMAT
    - 193rd BIT FORMAT - 100011011100 --- (REPEATED EVERY 12 FRAMES)
    - 192 BITS FORMAT - (24 8 BIT CHANNELS)

      BIT 8 OF THE 6th AND 12th CHANNEL RESERVED FOR VOICE NETWORK SIGNALING

The D4 format is defined for the voice designer but has some restrictive points for the data designer. The framing bit format is wasteful of bandwidth, and the robbing of the 8th bit of the 6th and 12th frame for network control is also wasteful for the data user. A new proposed extended framing format, Fe, (Reference 9.) is much more desirable but not yet available.

2.3.6 LOOPBACKS

- METALLIC PAIR (PINS 7 & 8)

  CUSTOMER EQUIPMENT MUST PROVIDE 750 OHM LOAD FOR 20 - 30 ma
  - LOCAL LOOPBACK (LLB)

    TURN ON - PIN 7 + WITH RESPECT TO PIN 8

    TURN OFF - TURN VOLTAGE OFF
  - TEST LOOPBACK (TLB)

    TURN ON - PIN 8 + WITH RESPECT TO PIN 7

    TURN OFF - TURN VOLTAGE OFF
  - INBAND SIGNALING (LLB ONLY)

    PROPOSED IN 193 BIT DATA FIELD

    TURN ON - 5 SEC OF 10000

    TURN OFF - 5 SEC OF 100

In-band loopbacks have been proposed, but no protocols have been adopted. A more desirable way would be to provide the loopback protocol in the framing bit format. It is burdensome for a designer to monitor the data field for 5 seconds of a given bit format.

2.3.7 KEEP ALIVE SIGNALING

- TYPE I - ALL BINARY ONES
- TYPE II - D4 FRAMING FORMAT AND THE 192 BITS ARE ALL BINARY ONES
- TYPE III - RECEIVE PAIR WRAPPED BACK TO TRANSMIT PAIR

These signals seem unnecessary for the data user and are a burden on the designer.

2.4 PERFORMANCE

The system design objectives as discussed in Reference 3. (when AT&T provides the customer terminating units) express the quality objectives as 95% error-free seconds, where the quality is measured while the system is in use or available. There are two ways to view the objectives:

1. The nature of the network causes the errors, usually of short term duration in groups or bursts with long periods of no errors. The specification (Reference 3.) suggests that, if one receives more than 300 errored seconds in any 15 minute interval, the trouble should be reported.

2. The other view, derived from the consideration of terrestrial facilities and the technology, compares the 95% error-free seconds as comparable to a bit error rate of less than 1 in 100,000 bits.

The error free seconds do not include the factor of availability. The availability objective is 99.7% measured over time of one year (12 consecutive months). This number comes from a statistical analysis of the circuit failure rate and repair time after the trouble is reported. Here again, this does not include the short transient degradations which do not require repair action. One aid offered to the user is that the telephone company and/or carrier can install automatic protection switchover equipment that will switch the traffic on the working channel to the standby channel when the preset threshold level is exceeded.

2.5 APPLICATIONS

This document discusses only two of the configurations of the High Capacity Digital Service: (1) customer premises to customer premises (point-to-point connection), and (2) customer premises to Serving Central Office (multiplex).

2.5.1 CPE TO CPE

The point-to-point user who has no requirements to channelize (in[illegible] 8-bit channels) the bit stream may use the bandwidth as desired. For applications where DTE to DTE connections require high volumes of transparent data to be continuously moved from one host to another, the hosts or controllers may choose to use their own protocols to communicate the data. In areas like host or controller to Private Branch Exchange (PBX) for channelized blocks of data, it may be desirous for the protocol to be standardized because of multi-vendor environments. Two proposals have been made in the Electronic Industries Association (EIA) standards group TR41.1 by Northern Telecom and AT&T-Information Systems. TR41.1 is drafting a standard for digital PBXs in which the High Capacity Digital Service will be one of the interfaces on the digital PBX.

The Northern Telecom proposal, Computer to PBX Interface (CPI), is intended to be an interim interface as industry migrates to the ISDN era. The use of existing PBX in-band (A and B bit) voice signaling and the mixing of data and voice may make implementing this approach easier. It may be somewhat short-lived because only the low speed protocols are supported, and no architected path is proposed for growth to the future of ISDN. The CPI proposal describes procedures for both asynchronous and synchronous protocol terminals up to 19.2 kbit/s attached to the PBX to be supported. The proposal defines a format of the DTE interface controls and the data from the DTE for transmission to and from the host. Additional equipment -- a Data Access Module (DAM) -- is required between each PBX interface and the DTE. The DAM is required to interpret and format interface controls and data for different protocols of the many DTEs that may be attached. The standard should be expanded to support up to 56 kbit/s terminals, including proprietary data terminals that may be attached behind a customer's PBX.

The AT&T-IS proposal of a Digital Multiplexed Interface (DMI) utilizes the channelized format of 23 channels for data and the 24th channel for signaling. The DMI proposal also requires a DAM at each interface and offers 64 kbit/s channels and compatibility with the proposed B8ZS (Reference 8.) for transparency and an implied ability to migrate to ISDN. The ability to support both speeds of 1.544 Mbit/s and 2.048 Mbit/s is desirable.

These two proposals are the first efforts to standardize an interface for High Speed Digital Service. The standard interface on this service should not require one of the units to be a PBX or the data stream to be all data or all voice. The connection, whether host to host, host to PBX, or PBX to PBX, should be the same.

The network for high speed has certain requirements. If the host to PBX interface can be made to match or be a superset/subset, then one interface could be used for both applications.

2.5.2 CPE TO NETWORK

The user of this option needs control of address or routing of channel segments through the network as implemented in today's voice network (Type I format interfacing into a D4 channel bank). The electrical interface should be the same as the point-to-point discussed earlier with additional requirements on the protocols or formats. It will require use of all available control bits and may even require using a separate signaling channel or circuit pair as proposed in Reference 5. Some digital applications may require more control information than presently used for the analog telephone and, thus, will require additional bandwidth as would be available from a separate channel.

2.6 TRENDS

One can conceive of many types of systems where units or boxes are interconnected by T1 point-to-point digital links. It is desirable that these connections not differ with different applications.

In these systems, however, hosts and PBXs (or Data Switching Units) will be required to dynamically allocate channels or slots to data or voice intermixed and treated the same. Protocols and efficiencies of the link will need to be the same for the new world of truly integrated voice and data.

In conversations between telephone companies and customers, it appears that installation times are becoming a problem. Some telephone companies are quoting from one to two years install dates for today's orders. Even though the user may view the T1 service as economically good, he may re-evaluate the application because of delivery schedules.

The TDC service is now offered to the data user as a channel in the voice network. Data users desire channels that are transparent to bit content and free of bit errors; these are difficult to obtain from the existing voice network using voice transmission techniques.

2.7 SUMMARY

These are interface requirements that restrict the data user to transparent use of the channel. A pulse density of a binary ONE within every fifteen (15) binary ZERO's must be observed. The interface circuits must never be disconnected, and one of the three types of keep-alive signals must always be present on the line. These restrictions are a hardship to the designer and a burden on the user. The equipment must continuously decode/generate the special bit patterns and remove any "fill-in bits" inserted in his data to comply with the bit density. The network also robs bits in certain frames for voice control. These controls are of no use to the data user, creating another useless search and decode of the data bits. All of this robs the user of channel use for data. A better approach for the data user would be to provide a "192 bit" unrestricted data field. This would offer full use of the channel for bulk data transfer or channelized into 64 Kbit/s channels if desired. Control of what data formats are used would be the responsibility of the user. Such a format (Fe) has been discussed but is not yet available. The additional function of Clear Channel (B8ZS) also has been discussed but is not yet available. When and if these two functions are available, the T1 channel will be more to the data user's liking. However, there still remains the problem of error detection, even with Fe.

The present TDC alert or error detection procedures are for voice application and are demeaning to the data user. An alert condition can take up to five (5) seconds to detect and advise the end user, and then it is not explicit about the problem. The problem may be a loss of sync, or it may be temporary facility degradation, or the network may simply decide to reroute the channel. The proposed Fe has a CRC error check imbedded in the framing format. It is desirable that this, or a similar function, be made available to the data user.

This paper shows the evolution of high speed service in the United States. Until September 1984 the user interface was via the 551A (AT&T provided) Channel Service Unit. Proposed tariffs are believed to require interface characteristics as described in Reference 3. If these characteristics are required, attachable units should be aware of the network and error detection capabilities of that service.

Data users considering this high speed service should investigate in detail the capabilities of the service and understand the lead time, functional aspects, and interface requirements.

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Note: Views and conclusions expressed in this paper are those of the author and are not necessarily those of the IBM Corporation.

Personal Computer-Based Communication Systems

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Abstract

This paper describes a potential alternative to commercial computer-based communication systems. Existing long distance telephone and/or radio services are used to connect microcomputers owned by the participants. Custom software carries out the computer-based exchange of previously-entered information much more rapidly than either party could type or speak the same material over the phone. Time zone differences and off-peak rate structures can be used to greatly reduce long distance charges levied by the information carriers. The real cost of the personally-owned system appears to be lower than that of the least expensive commercial alternative by roughly 50%.

Introduction

Many areas of the Pacific Hemisphere have great difficulty exchanging written information in a timely and affordable manner. Large geographic distances and numerous international boundaries make traditional forms of communication slow and expensive. Professionals wishing to conduct collaborative authoring, research, or training activities often find their efforts thwarted to the point of frustration.

Computer-based communication systems eliminate many time zone and distance barriers, but the fees charged by commercial systems of this type are often too expensive for individual use. Personal computer-based communication systems offer an opportunity for the timely exchange of written information at an affordable price.

System Description

The personal computer-based communication system used by the authors is composed of Apple IIe microcomputers containing Bell 103 type (300 baud) modems manufactured by D.C. Hayes. A single (160,000 character) floppy disk drive is used for mass storage. The software which performs the data exchange is a customized version of Southeastern Software's Data Capture 4.0. The Applewriter word processing program is typically used for entering information to be sent and manipulating the text after it is received. (A more detailed description of the system is contained in Lange, et. al., 1984.)

A message exchange with this system requires supervision by one or more humans. If a telephone line is used as the communication medium between two participants, then one participant can instruct his computer to direct-dial the computer of another, retrieve any messages waiting on the distant system and drop off new messages during the same connection.

This form of communication is used in the Texas-Hawaii exchanges. The Texas participant typically calls the Hawaii participant prior to 8 a.m. when long distance rates are the lowest possible. The call arrives between 2 a.m. and 3 a.m., Hawaii-time, and is answered by the computer left connected to the telephone by the Hawaii participant when he retires for the evening. The Hawaii participant wakes up in the morning to find new mail in his computer and has the whole day to think about and prepare a response to the Texas participant's statements. The sequence may be repeated the next evening or at some other mutually agreeable time.

Personal computer-based communication between American Samoa and Hawaii requires satellite ground station operators at each location and computers simultaneously manned by both parties involved in the exchange. The communication medium is the PEACESAT network on the ATS-1 satellite. The hardware and software at each location are identical to the "long-distance phone call" situation described above. A phone patch unit connects the computer's modem to the satellite ground station transceiver at each end.

In a typical exchange, the satellite ground station operators first make point-to-point voice contact with each other. Each operator then makes a phone patch connection to each participant and participant's computer. The participants then talk to each other and decide how many messages to exchange, who should send and who should receive, and other administrative details. Finally the receiver indicates his computer is ready to accept the first message, switches off his microphone, and waits for the sender to transmit. The sender transmits the message, waits several seconds after the complete message has been sent, switches off the modem connection, and speaks a message such as "That's the end of the text ... how was your reception?" The receiver then acknowledges the reception of the text and makes an on-the-spot judgment as to whether the transmission is sufficiently error-free to go on to the next message. If numerous errors are seen by the receiver as the 300-baud message is being displayed on his computer's screen, then ground station adjustments may be made and the message is re-transmitted.

Comparative Features

A number of desirable features can be identified for any personal message exchange system. Those which we have found to be most important are:

1. Message can be prepared on word processing system.
2. Message can be transmitted from sender's home.
3. Message can be received without leaving home.
4. Message is received in machine-readable format.
5. Message is delivered within one day after submission.
6. Message is transmitted virtually error-free.
7. Single message can be several pages in length.
8. Exchange is less costly than telephone conversations.

Table 1 shows which of the eight desirable characteristics are present in alternative message exchange systems. Only three systems satisfy all the requirements:

a. Personal Computer-Based Communication via telephone
b. Telex (RCA)
c. The SOURCE via Telenet

These three systems differ in cost (see Table 2) and convenience for domestic and international exchanges.

For domestic exchanges, a Personal Computer-Based Communication system is roughly 50% less expensive to operate than The SOURCE or Telex, but it is also much less convenient than the SOURCE. Telex is almost as expensive as The SOURCE and is less convenient because the computers on both ends must be available at the same time and an operator must establish the connection.

The relative advantages and disadvantages change for international messaging. Since no Telenet node is available in American Samoa, The SOURCE is not a viable option. International Telex rates are quite high, making computer-based communication via telephone the best of the three systems which meet all the requirements. However, personal computer-based communication via PEACESAT is even more economical than long-distance telephone.

PEACESAT offers advantages and disadvantages as a medium of exchange. In addition to low cost, major advantages include the ability to mix voice and data at will, and the ability to simultaneously broadcast a message to numerous locations. PEACESAT also reaches several locations in the Pacific Basin where even telephone service does not. On the side of disadvantages, the transmission quality of PEACESAT is such that a message must often be transmitted two or three times to complete the exchange of an error-free copy. Since PEACESAT is chartered to support only communication experiments, a messaging system may be denied access to the ATS-1 satellite as soon as it is no longer used for experimental purposes. In addition, the ATS-1 satellite has been in orbit much longer than its anticipated useful lifetime; no funding is currently available to replace ATS-1 when it ceases to function.

Implications for the Future

The recent deregulation and unbundling of communication services in the United States has made it possible for middle-man companies to build their own communication systems which take full advantage of the lower true cost now reflected on long distance bills. (Previously, long distance charges subsidized local services.) Examples of this type of company are MCI and GTE Sprint. These companies have been able to save the end user money and still make a profit precisely because they buy only the long-haul service from communication "giants" and offer specialized end-user services at a lower cost.

TABLE 1
ALTERNATIVE SYSTEM CHARACTERISTICS

	1	2	3	4	5	6	7	8
Personal CBC via PEACESAT	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Personal CBC via telephone	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
The SOURCE via Telenet	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Telex (RCA)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Telegraph	Yes	No	Yes	No	Yes	Yes	Yes	No
Facsimile	Yes	No	No	No	Yes	Yes	Yes	No
Federal Express Floppy Disk	Yes	No	No	Yes	Yes	Yes	Yes	No
Mailgram (Western Union)	Yes	No	No	Yes	Yes	Yes	Yes	No

TABLE 2
AVERAGE COST PER MESSAGE EXCHANGE
(342 Words, Most Economical Rates)

	Texas-Hawaii	Hawaii-Am. Samoa
Personal CBC via PEACESAT	---	$ 2.96
Personal CBC via telephone	$ 1.89	4.53
Telex (RCA)	$ 3.56	13.10
The SOURCE via Telenet	$ 3.67	---
Facsimile	5.64	---
Federal Express Floppy Disk	$ 19.00	---
Mailgram (Western Union)	$ 21.00	---
Telegraph (Western Union)	$ 153.90	$ 97.00

(Details regarding cost calculations are provided in Appendix A)

Deregulation allows a family or individual to carry the careful selection of communication services one step further. In addition to being able to buy an inexpensive long distance hookup from a middle-man company, it is now possible to construct and connect specialized communication devices to each end of the middle-man's system. This legal step has important implications for integrating written and spoken information media.

It is the opinion of the authors that the word processor has replaced the ball-point pen as the most convenient instrument available for writing non-trivial text. (Writing a paper for publication is one example of this type of activity.) We also believe that two-way, spoken communication continues to be preferable for informal exchanges which benefit from instantaneous human interaction. (Calling to wish someone happy birthday is an example of communication in this category.) A personal communication system is needed which allows two geographically distant people to exchange both types of messages without having to remember a post office box number in addition to a telephone number, and without having to stock envelopes and stamps and transportation to the post office for a message prepared without any need for these items. The participants should also not have to wait weeks or months for a reply.

The personal computer-based communication system used to establish benchmarks for this paper demonstrates the feasibility of an integrated communication medium. We believe it is now practical to build a much more convenient ("user-friendly") system with 1984 technology. In particular, devices such as the Texas Instruments Speech Command System ($2600) for the Texas Instruments Professional Computer allow an individual to record digitized speech on a floppy diskette and have the spoken message plus written text transferred through the telephone system at a pre-programmed time. The MacPhone system for the Apple MacIntosh may eventually offer equally impressive capabilities--it already contains a handset hanger on the side of the computer. The new Tandy 1000 comes with a standard option which allows the user to configure the system as an unattended message collection device.

With machines such as these and appropriate software in mass production, it is possible to foresee the day when middle-class households world-wide will have personal computer-based communication systems in operation. Owners will probably operate the telephone and word processor in traditional, non-integrated modes during productive hours even though the telephone and computer systems are physically connected to each other. (A person may talk on the phone while editing a word processing file, for example). At night, while people, personal computers, and personal telephone lines traditionally sleep, we can expect to find the computer and the telephone line carrying out traditional postal service functions under programmed control while the people sleep. A person will awake to find a computer filled with information instead of a newspaper on the front step or letters in the mail slot on the front door.

The implications for less developed Pacific Islands are equally far-reaching. It is still common on the outer islands of Fiji, one of the more economically stable Pacific Nations, to have just one telephone shared by all in a village.

Other Pacific Islanders have just one phone (or radio) per island or perhaps even none at all. International mail delivery to the most remote sites currently takes a matter of weeks or months. Communication with the outside world from such places is so slow as to be impractical for many potential applications.

Placing computer-based systems of the type we describe at the current locations of many telephones or two-way radios in the Pacific Basin would catapult the Pacific Hemisphere into the information age. The most expensive required component, the communication medium, is already in place. Computer-based communication would simply increase the efficiency of the medium's use. As islanders learn word processing and other computer applications, an important by product would emerge as well--that of computer literacy.

Reference

Lange, James and others. ATS-1: Social Service Satellite Networks in the Pacific. Papers and Proceedings of the Sixth Pacific Telecommunications Conference. Honolulu: Pacific Telecommunications Council, 1984, pages 109-118.

Appendix A
Message Exchange Cost Calculations
Denton, Texas to Honolulu, Hawaii

Personal Computer-Based Communications via PEACESAT

(not available)

Personal Computer-Based Communication via Telephone:

(based upon 14 messages exchanged June-July, 1983)
Total Billed Time = 83 minutes
Total Telepnone Charge = $26.39
Total Number of Words Exchanged = 4793
Average Duration of Exchange Session = 83/14 = 5.93 minutes
Average Number of Words Exchanged = 4793/14 = 342 per session
Average Cost Per Message = $26.39/14 = $1.89

The SOURCE via Telenet:

SOURCE/Telenet Charge from Honolulu = $.25 per minute
SOURCE/Telenet Charge from Dallas = $.21 per minute
Long Distance Connection, Denton to Dallas = $.12 per minute (assume computer program types message into SOURCE file)
Cost for Honolulu Sender or Reader = 5.93 x .25 = $1.48
Cost for Texas Sender or Reader = 5.93 x (.21+.12) = $1.96
Total Cost Per Exchange = Sender Cost + Reader Cost = $3.44

Telex (RCA):

(No-Minimum) Point-to-Point Data Connection = $.60 per min. (assume computer program types message to receiving computer)
Cost Per Exchange = 5.93 minutes x $.60 per min. = $3.56

Facsimile:

Service Charge = $7.50 per page
Telephone Charge = $ .53 per page
Total Charge = 2.50 + (5.93 x .53) = $5.64

Air Freight Floppy Disk (Federal Express):

Overnight Delivery, 6 oz., envelope provided = $19.00

Mailgram (Western Union):

350 words plus name and address = $21.00

Telegraph (Western Union):

Charge for first 10 words = $8.75
Charge for each additional word = $.45
Total Charge Per Exchange = 8.75 + (332 x .$.45) = $153.15

Honolulu, Hawaii to Pago,Pago, American Samoa

Personal Computer-Based Communication via PEACESAT:

Estimated Station Operation Cost Per Year = $18,000
Time Available = 5 days/wk. x 30 wks./yr. x 8 hrs./day x 60 min./hr. = 72,000 minutes Operating Cost Per Station Per Minute = 18000/72000 = $.25
Sender or Receiver Cost Per Exchange = 5.93 x .25 = $1.48
Total Cost Per Exchange = Sender + Receiver Costs = $2.96

Personal Computer-Based Communication via Telephone:

Telephone Charge = 2.50 for 1st minute -- .92 for additional minute
Total Charge = 2.50 + (4.93 x .92) = $4.53

The SOURCE via Telenet:

(not available)

Telex (RCA):

Connect Charge = 2.21 per minute
Total Charge = 5.92 x 2.21 = $13.10

Facsimile:

(not available)

Air Freight Floppy Disk (Federal Express):

(service not available overnight)

Mailgram (Western Union):

(not available)

Telegraph (Western Union):

Charge Per Word (address also charged) = $.27
Surcharge Per Message = $2.50
Cost Per Exchange = (350 words x .27) + 2.50 = $97.00

ON THE MECHANICAL GENERATION OF EXCHANGE PLANNING ALTERNATIVES FOR USE IN A PORTFOLIO ANALYSIS PROCESS - PROBLEMS AND SOLUTIONS FOR A TELEPHONE COMPANY

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1. Abstract

As telephone companies move into a more competitive business environment, more emphasis is being placed on the proper selection of investments (portfolio analysis). At present, however, the environment is still associated with a degree of regulation; hence investment opportunities retain considerations of local growth.

This paper will cover the portfolio analysis process, the logic for determining exchange planning alternatives, including modernization as input to that process and how that combination presents an *untrivial* problem. Additionally the paper will cover trade-offs for heuristically solving the problem. Finally, the paper will discuss a software solution being developed within GTE as part of the Capital Program Management System (CPMS).

2. THE PORTFOLIO ANALYSIS PROCESS

This process is used to select the optimum set of alternatives from a given set of alternatives based on the following problem:

$$\textit{maximize} \sum_{i=1}^{g} V_i S_i \qquad (1)$$

Where: g = total alternatives in the given set
V_i = net present value of alternative i
S_i = selection criteria for alternative i

$$S_i = \begin{cases} 0 = \text{reject} \\ 1 = \text{accept} \end{cases}$$

Subject to:

$$\sum_{k=1}^{T} \sum_{i=1}^{g} P_{i,k} \quad S_i \quad \leq \quad K_k \qquad (2)$$

Where: T = total number of constraints
$P_{i,k}$ = the value of the constraining factor of type k associated with alternative i
K_k = the total value of the constraining factor of type k.

Now assume there are subsets of g such that:

$$g = \sum_{j=1}^{J} N_j \qquad (3)$$

Where: N_j = the number of alternatives in the jth subset

If there exists subsets in which one but no more than one alternative must be selected, then the following constraint is imposed for each such subset:

$$1 = \sum_{z=1}^{N} S_z \qquad (4)$$

Where: N = the number of alternatives in the subset

So far, all alternatives have been considered as binary, i.e. do or don't do. Some additional alternatives can be continuous, i.e. do any percentage of the plan. An example would be a plan to replace old air core buried cables with filled cables. The result of the optimizer run would indicate the percentage of the total plan that could be afforded in respect to the total portfolio.

The output set θ of the portfolio analysis process is defined as follows:

$$\theta \in g \tag{5}$$

- or -

$$\theta = (a \mid a \leq g) \tag{6}$$

Where: a = all selected alternatives

In addition, we can state that:

$$\forall a \longleftrightarrow \left[\forall a\ (a') + \exists a\ (a'') + \forall a\ (a''')\right] \tag{7}$$

Where: a' = must do alternatives

a" = sets of related alternatives
a'" = alternatives chosen from sets of mutually exclusive alternatives defined in expression (4)

Neither *linear programming* nor *integer programming* techniques can be adequately used to perform the optimization since some alternatives are binary and some are continuous; therefore a *mixed integer programming* technique is used to select the portfolio.

Figure 1 is an overview of the portfolio analysis process.

After reviewing the methodology involved in developing alternative plans, we will return to the subject of portfolio analysis to discuss problem areas.

3. FUNDAMENTAL PLANNING IN A TELEPHONE COMPANY

Within a telephone company, the fundamental planning process involves the study of central office serving areas in respect to present and forecasted demands. These studies include considerations of present and future technologies. There are two main components or classes of plant involved, i.e. central office equipment (coe) and outside plant (osp).

The central office serving area shown in Figure 2 is composed of four feeder routes extending from the central office with ten control points on each route. Control points are locations where it is desirable to analyze the route. They occur at locations such as intersections of highways and at physical locations where changes in the osp network result.

The technology employed in the central office will have an impact on the types of osp facilities that can be placed. The fundamental planner must consider if the present central office equipment is to be retained or if there is a market for services that can only be provided by a new technology. All of these considerations must be made in respect to timing and cost as well as risks.

4. DEVELOPMENT OF PLANNING ALTERNATIVES

As a starting point, consider a sample central office serving area where six basic alternatives exist for coe. These are either to grow with the existing technology (present method of operation or pmo) or to convert to a new technology such as digital switching in any office years, $Y_1 - Y_5$. In each of the conversion alternatives, existing technology is used until the conversion year, then replaced with a new technology and local growth after conversion provided for by the new technology.

For the osp portion, we also have six basic alternatives since the conversion itself and the year of conversion will impact the types of osp facilities which can be used. For example, the use of remote digital pair gain units may be possible only with the new technology to be used for coe.

5. THE PROBLEMS BEGIN

Returning for a moment to the subject of portfolio analysis, we can postulate that in order to improve the probability of selecting the truly optimum portfolio, we should input as many of the possible alternatives from the universe of all alternatives that we can.

It is important to realize that the most economical alternative in a set of mutually-exclusive alternatives may not be the one chosen when considered in the set of all alternatives. This results from the influence of the various constraints during the optimization process.

In the development of the alternatives, we started with six basic ones but no mention was made of variations in facility sizes. When sizing variations are introduced new alternatives emerge; so much so that the optimization problem is an *untrivial* one. Appendix 'A' provides more details on the magnitude of the problem.

Another problem area is in the accuracy of the base data. In order to have an efficient method of developing cashflow input data (annual investment, expenses and revenues) associated with each alternative, detailed pricing is impractical and cost estimates are modeled on an $a+bx$ basis. Over certain size ranges the linear curve may introduce price inaccuracies of about five percent. In addition, forecast data usually have a margin of error of at least five percent. With such margins of error, we should never expect to have more than 90 percent probability of selecting the optimum portfolio, no matter how good a job we do in identifying alternatives.

6. TRADE-OFFS

Since we know it is impossible to select the *truly optimum portfolio* we can make some educated assumptions to pare down the problem to a manageable level.

First of all, economic order quantity (eoq) models exist for determining the most economic facility size to be placed in respect to rates of growth, average unit costs, inventory costs, etc.

Consider that a plan alternative composed of eoq-selected facilities will probably have the best net present value of all the alternatives in the set of mutually-exclusive alternatives for a central office serving area. Since alternatives with larger than eoq-selected sizes will have a lower net present value, these need not be included in the set to be optimized and thus do not even need to be formulated. We therefore develop all initial alternatives based on the most economical sizes (or standard intervals between additions if desired). If we are aware of capital constraints in the early years, we can vary one or more of these alternatives by reducing the sizes of the facilities in the early years and adjusting the relief interval. The basic strategy is to generate alternatives based on existing plans and standards and the planner's knowledge of the business environment. Each alternative would contain the heuristically-determined most economical facility sizes. The planner would then adjust or create new alternatives by mimicing alternatives and adjusting data or changing parameters based on his knowledge of practical considerations.

7. METHODOLOGY

Figure 3 is a Warnier-Orr chart showing the generalized methodolgy for creating planning alternatives. Sizing algorithms, expense estimating and revenue estimating algorithms, etc. have not been shown but are a part of the overall process.

There are two basic paths; one for pmo and one for conversions. In essence, facilities are matched against demand in each forecast year and if inadequate, an addition is sized and costed. Building space requirements are also reviewed and handled accordingly. The planner then reviews the cash flow results and determines which alternatives are to be forwarded to the portfolio analysis process.

8. DEVELOPMENTS

The Capital Program Management System (CPMS) is being developed within GTE. It uses software to generate plan alternatives for central office serving areas, performs cash flow calculations and performs the optimization process. Optimization is done via leased software while the other portions are being developed within GTE.

Some user-oriented features are the ability to use telco-specific algorithm data and the ability to adjust the cash flow input data developed by the algorithms to better reflect what is expected. This allows the planner to fine tune alternatives. An important point is that as with any model it only depicts reality and contains some compromises. Because of this, the actual project developed will vary in facility sizes and timing to some degree. This is a matter of working with more up-to-date and detailed information and does not invalidate the model.

9. SUMMARY

The mechanical development of planning alternatives of central office serving areas and the analysis of them to select an optimum portfolio is an *untrivial* problem. Heuristic procedures and planning knowledge can be used to reduce the set of generated alternatives to a manageable set and include those which would normally be selected by an optimization process. The use of these software tools should allow the planner to examine efficiently many more alternatives in respect to capital requirements than has been possible before.

10. ACKNOWLEDGEMENTS

Various people, too numerous to name individually, have reviewed and commented on previous unpublished works of mine which provided the basis for this paper. I would like to single out Dr. Ron Marshall, whose unpublished work (see references) inspired the writing of Appendix 'A'.

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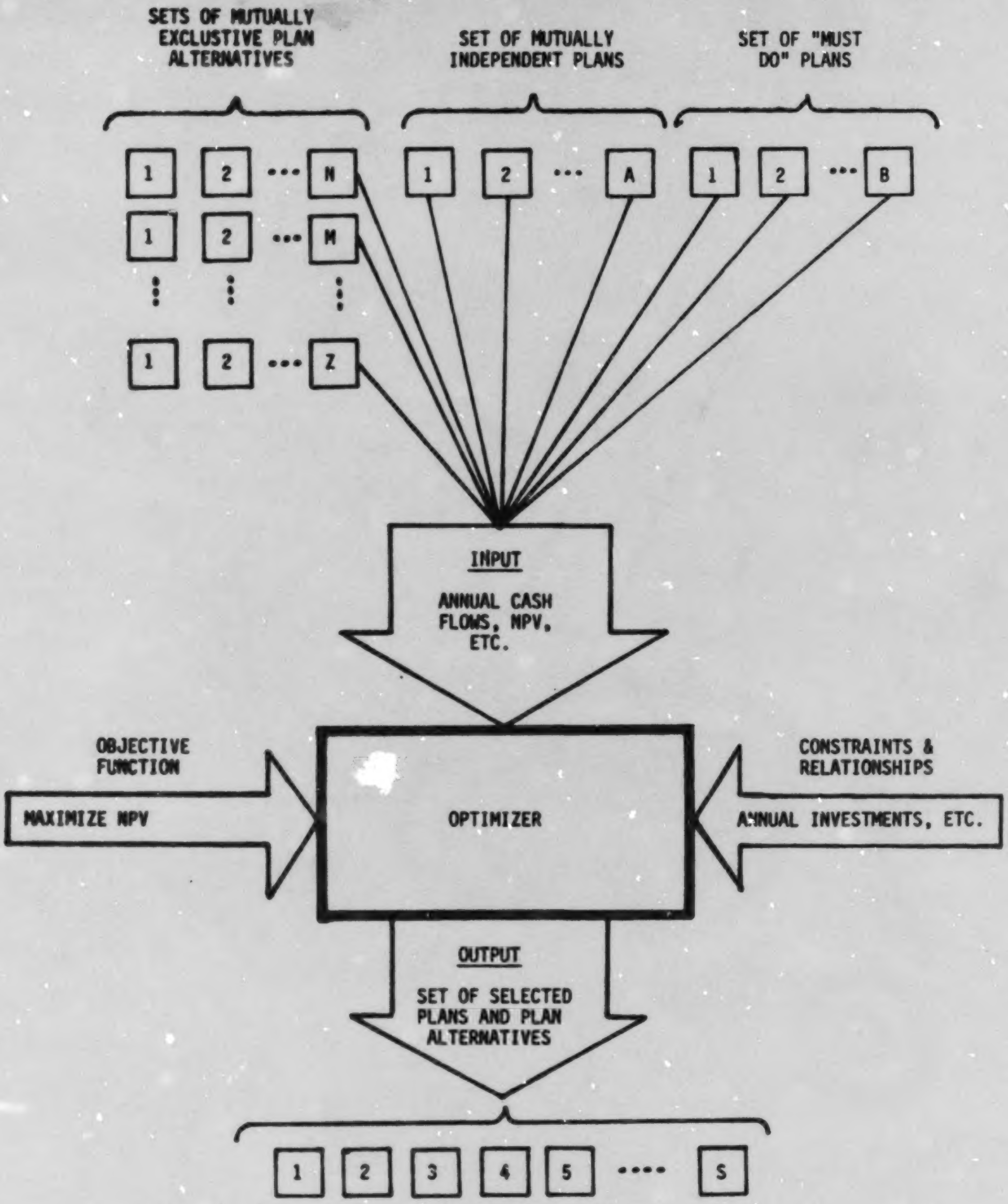
SETS OF MUTUALLY EXCLUSTIVE PLAN ALTERNATIVES
SET OF MUTUALLY INDEPENDENT PLANS
SET OF "MUST DO" PLANS
1
2
N
1
2
M
1
2
Z
1
2
A
1
2
B
INPUT
ANNUAL CASH FLOWS, NPV, ETC.
OBJECTIVE FUNCTION
MAXIMIZE NPV
OPTIMIZER
CONSTRAINTS & RELATIONSHIPS
ANNUAL INVESTMENTS, ETC.
OUTPUT
SET OF SELECTED PLANS AND PLAN ALTERNATIVES
1
2
3
4
5
S

FIGURE 1

OVERVIEW OF PORTFOLIO ANALYSIS

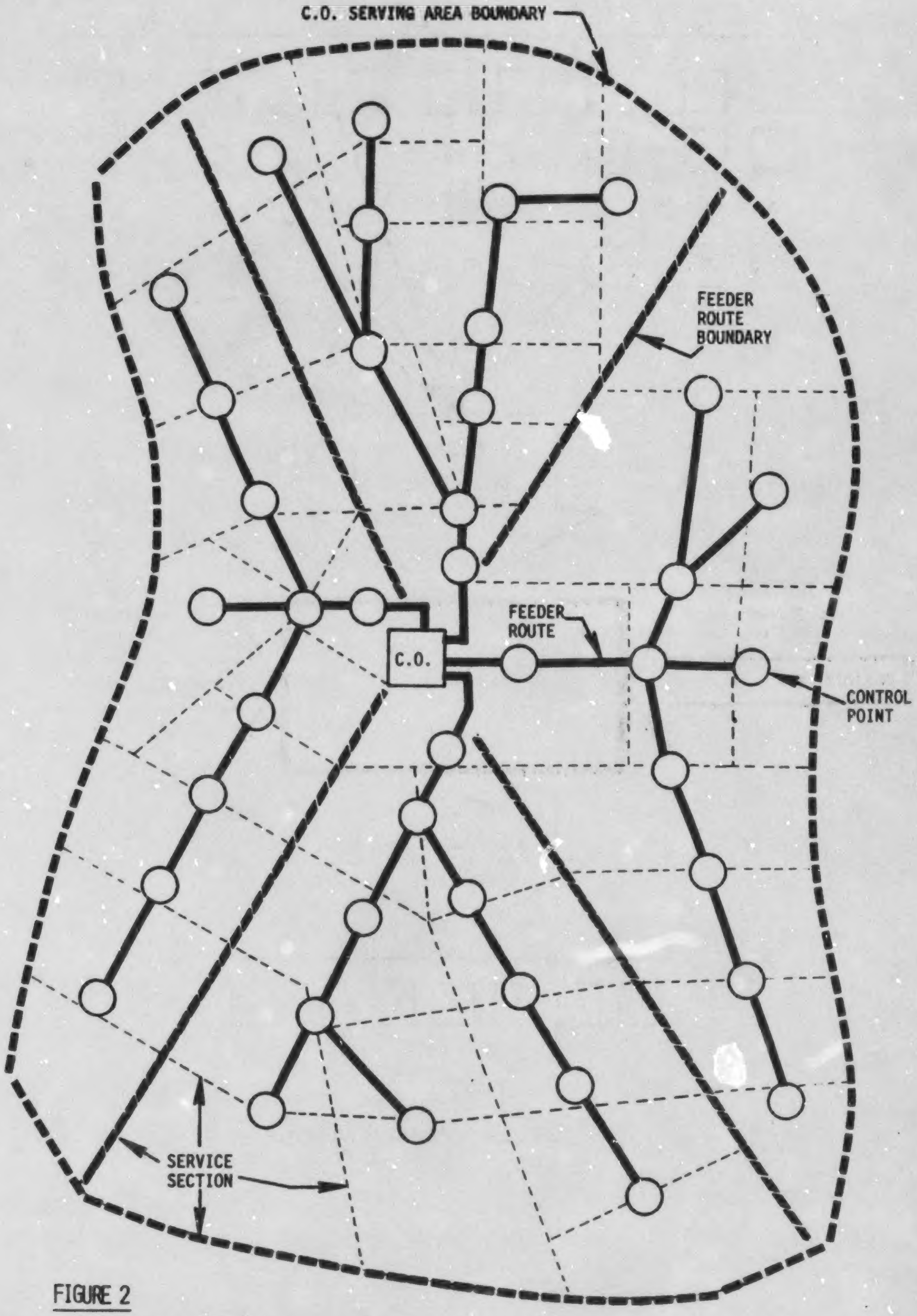
C.O. SERVING AREA BOUNDARY
FEEDER ROUTE BOUNDARY
FEEDER ROUTE
C.O.
CONTROL POINT
SERVICE SECTION

FIGURE 2

C.O. SERVING AREA

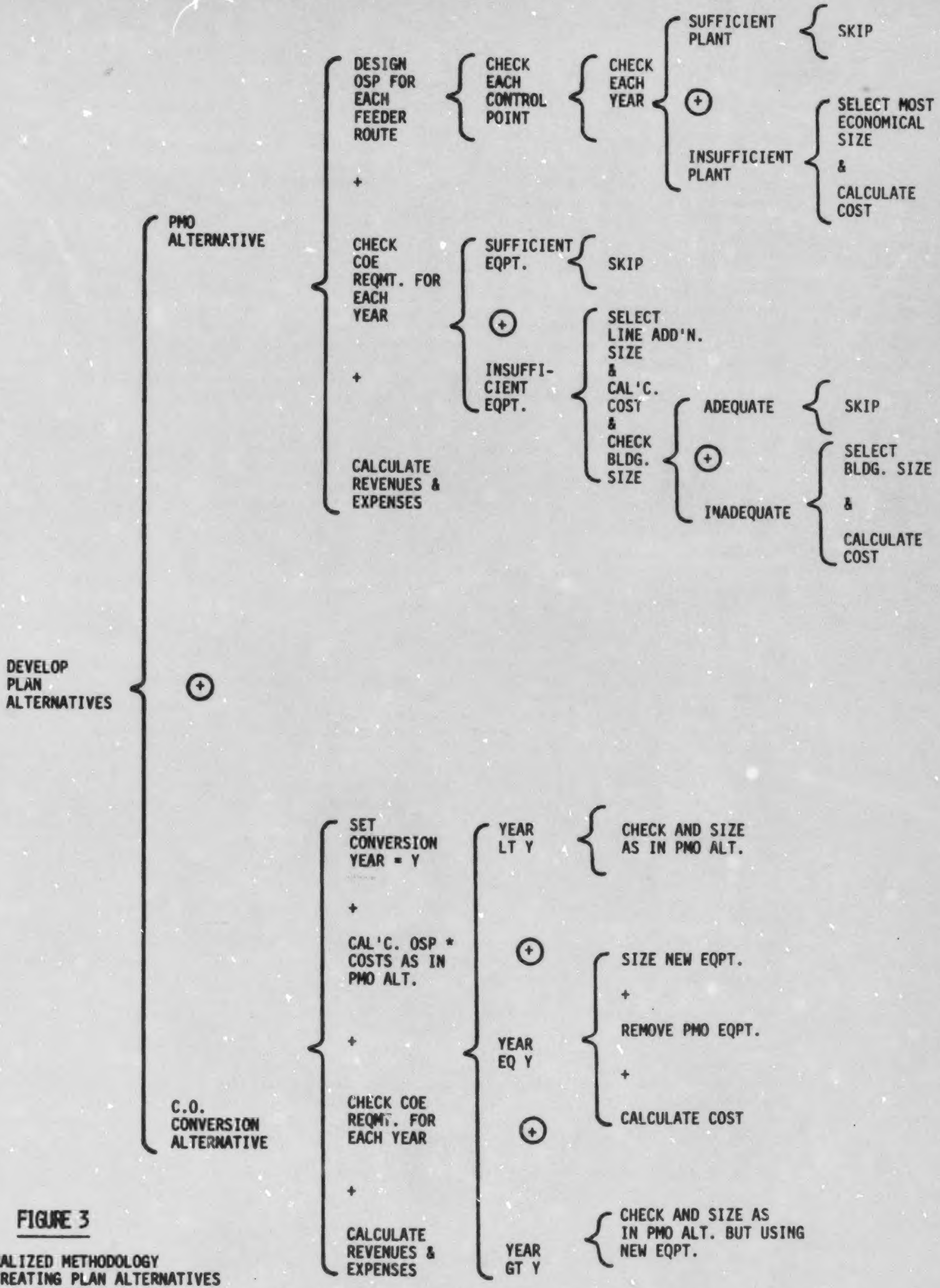
DEVELOP PLAN ALTERNATIVES
PMO ALTERNATIVE
DESIGN OSP FOR EACH FEEDER ROUTE
CHECK EACH CONTROL POINT
CHECK EACH YEAR
SUFFICIENT PLANT
SKIP
⊕
INSUFFICIENT PLANT
SELECT MOST ECONOMICAL SIZE
&
CALCULATE COST
+
CHECK COE REQMT. FOR EACH YEAR
SUFFICIENT EQPT.
SKIP
⊕
INSUFFICIENT EQPT.
SELECT LINE ADD'N. SIZE & CAL'C. COST & CHECK BLDG. SIZE
ADEQUATE
SKIP
⊕
INADEQUATE
SELECT BLDG. SIZE
&
CALCULATE COST
+
CALCULATE REVENUES & EXPENSES
⊕
C.O. CONVERSION ALTERNATIVE
SET CONVERSION YEAR = Y
+
CAL'C. OSP * COSTS AS IN PMO ALT.
+
CHECK COE REQMT. FOR EACH YEAR
+
CALCULATE REVENUES & EXPENSES
YEAR LT Y
CHECK AND SIZE AS IN PMO ALT.
⊕
YEAR EQ Y
SIZE NEW EQPT.
+
REMOVE PMO EQPT.
+
CALCULATE COST
⊕
YEAR GT Y
CHECK AND SIZE AS IN PMO ALT. BUT USING NEW EQPT.

FIGURE 3

GENERALIZED METHODOLOGY FOR CREATING PLAN ALTERNATIVES FOR A C. O. SERVING AREA

* SAME LOGIC IS USED

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APPENDIX 'A'

A NUMERICAL EXCURSION INTO THE CREATION OF MUTUALLY-EXCLUSIVE ALTERNATIVES

In the body of the paper six basic alternatives were developed. Assume that for coe facilities any of three engineering intervals (time between additions) can be used such as 2, 3 or 4 years. This increases the number of alternatives to:

(6 alts/eng int) (3 eng int) = 18 alts.

Now exploring the osp considerations, take one of the four feeder routes. There are 10 control point segments and we will assume that any of 5 cable sizes could be selected to provide relief in a segment when required. (The sizes would vary between the segments.) At first it would seem that the possibilities of arranging the choices would be 5 x 10 choices permuted among themselves, but it is really only 5^{10}= 9,765,625 possibilities. If we consider that either standard or fine gauge transmission designs can be used then the number doubles to 19,531,250.

For any of the non-pmo alternatives (15), assume that a remote pair gain unit can be placed at any or all of three control points and these would require either existing cable, new screened cable or optical fibers for the host-remote links. This adds (3!) (3) = 18 new alts. So far the number of alternatives are as follows:

-pmo
(3) (19,531,250) (4) = 2.34×10^8
-non-pmo
(15) (19,531,250) (4) = 1.17×10^9
-total
1.41×10^9

Consider also that for either pmo or non-pmo we could place pair gain units (with a central office terminal in pmo alternatives) at any one or all control points, and use existing cable as the transmission medium. This adds (40!) (18) = 1.47×10^{49} new alternatives. Adding the 1.41×10^9 to this essentially does not change the number so we can say that we have 1.47×10^{49} alternatives.

Consider that for each alternative there would be at least one expenditure per year for a 20 year planning horizon. Also assume that for each expenditure about 10 computer instructions are required to perform the calculations necessary for the modeling, costing and the cashflow study prior to the portfolio analysis process. This means that a telephone company with 100 central office areas of this type would require about:

(2.94×10^{53} inst) (1sec/14.3×10^6 inst)* (1 yr/3.16×10^7 sec) = 6.50×10^{38} years.

Recalling that about 15 billion years have elapsed since the big bang, we find that (6.05×10^{38}) / (3.16×10^7) = 1.91×10^{31} mainframes working since the dawn of time would have been required to process this data!

Now in all seriousness, I can state that I have not played fair since many of the alternatives, though possible, are not practical and any good planner would not even consider them. Additionally, many alternatives would have very little difference in net present value and experience would show which could be discarded. I have not, however, included any non-modelable alternatives such as refeeding or boundary changes. It is rather like *Gödel's Incompleteness Theorem;* no matter how many alternatives you explore, you can't be sure that there isn't a better one left unexplored.

Although we played the numbers game, there is good news. The problem can be solved heuristically with certain trade-offs. These are covered in the body of the paper.

**Based upon 14.3 million instructions per second for a typical mainframe*

DIGITAL DEMOCRACY:
The Alaska Legislative Computer System

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Interface
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Abstract

This paper discusses the operation of ALECSYS, the Alaska Legislative Computer System, with particular emphasis on its uses within the state's legislative information system. It provides a summary history of the Alaska Legislative Information System and a detailed description of the legislative computer network, ALECSYS. Such systems represent the early forms that telecommunication services may take in public participatory systems. As such, ALECSYS provides some insight to the problems of providing these services.

1. CONTEXT

Alaska has long been known for its difficult climate and geography. Development of basic infrastructures in the state has been hampered by these two elements. Communication and transportation links have been particularly difficult to establish. Political participation was slow, indirect, and based on limited information. The situation has been exacerbated by the location of the state's Capitol in Juneau, inaccessible by land and remote from the bulk of the state's population.

Since the mid-seventies the state has taken bold steps to alleviate the problems of inadequate communication systems. Massive efforts to network the isolated communities throughout Alaska with audio and video teleconferencing, facsimile, and broadcast television were underwritten by the state's unprecedented wealth due to royalties from the TransAlaska oil pipeline.

At the end of 1984, 99 percent of the state has telephone service. In some rural villages this is limited to a single telephone. All communities have emergency medical communication services. Teleconferencing through state funded systems is available to over 93 percent of the population; data service to over 86 percent (1). Broadcast TV is provided to almost all communities of 100 or more residents. While such availability to telecommunication services seems normal for the United States, Alaska must be measured against a different standard. In 1970 a majority of Alaskan communities had none of these services (2). Within a few years all of the state was connected electronically. In short, there has been an aggressive and accelerated program of development in Alaskan telecommunication.

2. THE ALASKA LEGISLATIVE INFORMATION SYSTEM

Readily available lines of communication between elected state officials and voters has been difficult in Alaska. During the first years after statehood (Alaska became a state in 1959) the legislative session was routinely adjourned so committees could travel around the state to solicit citizen input. Beginning with a series of experiments in 1977 a two network system was established to directly address this problem. The system provides diffusion of information on the legislative and other branches of state government and established a means of interaction between legislator and constituent. All general services provided by the networks are free.

2.1 THE LEGISLATIVE TELECONFERENCE NETWORK

The Legislative Teleconference Network (LTN) provides audio (some video) teleconferences for committee hearings, constituent meetings, and legislative work sessions. It consists of 67 teleconference sites, 45 of them connected by a four-wire dedicated line. Teleconference participants using the public telephone system can also access the network. Facsimile is available over the dedicated line as well.

2.2 THE LEGISLATIVE INFORMATION NETWORK

The Legislative Information Network (LIN) is composed of 17 information offices, located at population concentrations around the state. In addition to serving as teleconference sites on the dedicated line, information offices are connected through the Alaska Legislative Computer System (ALECSYS). The offices serve as both dissemination spots for information on the legislature and contact points for constituents and legislators.

The Legislative Information Network predates the LTN and offers a variety of services that are valuable without teleconferencing. It began with a volunteer-run office in Anchorage, the state's largest city, in 1976. The first year of operation as a network was in 1978. All information offices have at least one copy available of current bills, the state constitution, state handbook of government, and uniform rules for the legislature. Juneau, Fairbanks, and Anchorage offices also contain hard copies of the following:

1) House and Senate Bills back to 1975 including final status of bills and resolutions and House and Senate bill histories.

2) All resolutions.

3) All session laws back to 1913.

4) Summaries of legislation passed from 1975 to the present.

5) Alaska Administrative code, updated quarterly.

6) House and Senate Committee meetings with weekly updates.

Other information offices have some of these materials depending on their size. The three urban offices have small libraries with various legislative and other state government documents. All offices and teleconference sites have access to these materials. It simply takes a little longer to obtain requested copies for citizens living outside the major urban areas.

2.3 SYSTEM ADMINISTRATION

The system is operated by the Division of Public Services, a branch of the Legislative Affairs Agency. The agency is the administrative arm of the Legislative Council, a group of twelve legislators chosen by the leadership of the House and Senate. The council is a standing committee which handles legislative matters during the interim. It sets policy which the Legislative Affairs Agency carries out. All requests for system expansion must go through the Legislative Council. Planning does not extend far beyond two years (3), the time between state elections for all representatives and half the senators.

3. ALECSYS: THE SYSTEM

A key connection for the LIN is by computer. All information offices are connected to the Alaska Legislative Computer System (ALECSYS) which provides extensive information retrieval services and communication utilities. The current system came into general use in 1978 (4). The LIN and the state Ombudsman Office, share the computer and software.

ALECSYS is operated by data processing division of the Legislative Affairs Agency. Data processing is divided into three areas:

1) Programming
2) Data Center -- work with host system and peripheral equipment.
3) User Services -- trouble shooting, training, and support.

An advisory group, composed of a cross-section of users was established in June of 1984 to provide input on user needs and offer suggestions concerning training and support materials (5).

3.1 HARDWARE

The ALECSYS host computer is an IBM 3083 CPU (Central Processing Unit). The 3083 has an 8 megabyte working memory and a speed of 3.75 mips (million instructions per second).

Five types of terminals are used in legislative offices, all of them IBM. These include IBM 3278's, 3279's, 3290's and 3270 PC's. IBM Displaywriters are also used as a 3270 terminal in some offices. Televideo terminals are often used for dial-up legislative users. Other dial-up users may use other types of terminals as long as they meet system protocols.

The PC's have been recent additions to the system. They permit users to process four interactive screens simultaneously. Each PC has two internal note pads that provide working storage space. To the host computer, a PC working on four programs at once appears as four separate terminals. The multiple access is useful when staff are working in one program and need access to another for a particular piece of information. The PC's can also be used as stand alone microcomputers. The only information offices with PC's are in Juneau, Anchorage, and Fairbanks where the quantity of work warrants more powerful terminals. These three urban offices have IBM 3274 control units which can support 16 to 24 terminals. The microcode in the 3274 is programmable and erasable, allowing more local flexibility. Other offices have IBM 3276 control units with microcode in PROM (Programmable Read Only Memory) and the ability to support one or two terminals.

All legislators have an ALECSYS terminal in their office. Some have purchased personal computers and the necessary peripherals and software to access ALECSYS as dial-up users.

ALECSYS is connected to five other mainframes in Alaska. All are operated by other branches of state government. They include two administration mainframes in Juneau, two in Anchorage, and the Commercial Fisheries Entry Commission computer in Juneau. Early in 1985 ALECSYS will connect with the state Department of Labor mainframe, also in Juneau. All of these are IBM computers. Connection to them is by modem over a dedicated line. There is no current ALECSYS connection to any data base outside Alaska.

Telecommunication through ALECSYS is handled by IBM 3705 front end processors (minicomputers) in Juneau and Anchorage. The Juneau 3705 handles the capital area and several cities in Southeastern Alaska. The Anchorage 3705 controls the immediate metro area and all points north.

Communication links are provided through ALASCOM, the state's primary longlines carrier. It is a dedicated four-wire circuit similar to the one used for the teleconference network. It links all information offices and terminal locations in Juneau. Data transfer to and from Juneau is at 9600 baud. A recently installed fiber optics system connects ALECSYS terminals located in three government buildings in Juneau. Telecommunication on this system goes at the more respectable rate of 16000 baud.

Dial-up users access the system through ports in information offices in Juneau, Anchorage, and

Fairbanks. Anyone living in other areas must place a long distance call to one of those locations. Each has two ports for legislative dial-up users and two ports for non-legislative dial-up users. Thus, a total of twelve dial-up users may access ALECSYS at any one time (6).

3.2 SOFTWARE

IBM is the primary software provider. Applied Data Research (ADR) has supplied some program development software. A few other sources have been used from time to time and some software is developed by data processing staff (7). The IBM Systems Network Architecture (SNA) software is used for telecommunication.

Although information offices have access to most ALECSYS programs, they use only a few of them. A number of other state agencies also have access to system data bases and applications programs. What follows is a brief description of the programs available on ALECSYS. Table 1 is an explanation of acronyms. I will discuss in detail only those programs used most heavily by information offices.

Table 1

ALECSYS Programs

Advanced Text Management System (ATMS)
Storage and Information Retrieval System (STAIRS)
Bill Action Status Inquiry System (BASIS)
Electronic Mail (EMAIL)
Statute Inquiry Reference System (SIRS)
Graphic Data Display Manager (GDDM)
Election District Locator System (EDLS)
Systems Development (ROSCOE)
Computer Availability (NEWS)
Teleconference Schedule (TELE)
House Committee Schedule (HCSE)
Senate Committee Schedule (SCSE)
Ombudsman Caseload System (OMBD)
Dept. of Admin.--Juneau Data Center (JDC)
Dept. of Admin.--Anchorage Data Center (ADC)

source: Alaska Legislative Computer System, 1984

ATMS is a text processing and editing system. Memos, letters, mailing lists, forms, and almost any variety of document may be created and stored on it. Since information offices have IBM Displaywriters or IBM PC's for word processing, they make little use of this program.

STAIRS is a retrieval applications program designed by IBM. The ALECSYS version currently has 25 data bases including information on Alaska Statutes, session laws and annotations, captital and operating budgets, legislative committee meeting minutes, journals from each house, executive orders, legislative rules, and Ombudsman closed case files (8). It uses key words or phrases to search. Information can also be called up by specific bill and by house or senate versions. The program presents an initial menu, but is then free form for searches. Committee minutes are entered about two weeks from the time of a hearing or meeting. The minutes include testimony and information on witnesses (name, address, telephone number). Information office staff conduct searches for the public because of familiarity with the command language (9) and access to STAIRS requires a password. Information contained in STAIRS is available to the public. Requests for Ombudsman data must go through that office. The staff of individual legislators make heavy use of this system.

BASIS is the only data base open to direct public use in information offices. It was originally a batch only program which has been adapted for on-line use (10). Its command language is fairly simple to master. It is menu driven. BASIS is a journal index system reflecting the daily activities of the legislature. Each bill or resolution entered contains the title, sponsor, fiscal information, and [illegible] pertinent activity. This includes committee referrals, floor action, and vote tallies. For further information the Legislative Journal page number containing a record of the action indicated is provided. The printed journal is available in the information offices. BASIS is updated daily.

EMAIL is a message processing system. It provides electronic mail between all information offices. Other legislative agencies also use EMAIL for communications, although information offices and the teleconference network are the biggest users. It is not open to public use; however, citizens, through LIN staff, may send a Personal Opinion Message (POM) to any legislator(s). POMs will be discussed in greater detail later. Access to EMAIL is by password and varying degrees of clearance can be assigned (11). EMAIL is a primary tool for efficient communications throughout the legislative information system.

SIRS is an index of Alaska Statutes. Searches are generally done by statute number. It is another menu driven program.

GDDM provides the ability to display and print multicolored graphics. Access is limited. It is used by legislative budget staff to prepare graphics for reports. Very little use is made of this by information offices; none by the public.

EDLS provides information on the geographic make-up of election districts. Searches are done by identifying a specific location in the state (borough, city, village). It was developed by Data Processing personnel (12). It uses a free format for searches.

ROSCOE is not used by information offices. It is an interactive program development system utilized by data processing staff.

NEWS provides internal information concerning the computer system.

TELE is a current listing of legislative teleconferences. It is updated daily by Juneau information office staff.

HCSE provides an up-to-date schedule of committee meetings held in the House.

SCSE provides an up-to-date schedule of committee meetings in the Senate.

OMBD is the Ombudsman's caseload management system. Access is limited to Ombudsman staff. This limited access is mandated by statute to protect the privacy of the information in case files.

JDC and ADC are primarily used by personnel in Juneau for data work. They provides access to administrative mainframes located in Juneau and Anchorage, respectively.

STAIRS, BASIS, TELE, NEWS, HCSE, SCSE, EDLS and EMAIL are the main programs used by information office staff. Information in the data bases of all with the exception of EMAIL is available to the public. Direct access to STAIRS is done by staff not only because of their familiarity with the command language, but to avoid having the computer tied up with too many users searching the available data. Lawyers, in particular, were mentioned by Carol Dickason, then coordinator of information offices, as one group that could easily run endless searches on minute details of statutes (13).

3.3 POMS

Via ALECSYS citizens can send Personal Opinion Messages (POMs) to any or all legislators. Messages can come from any information office. They are limited to fifty words, and sent by information office staff over EMAIL. Organizations are not allowed to use the service to send identical messages to all legislators. The intent is to provide a mechanism for individuals to express their opinion to legislators. There is no limit on how many POMs any individual may send nor to whom. Messages will be accepted over the telephone if travel to an information office is not possible (collect calls are accepted).

POMs are treated as private correspondence between constituent and representative. The only record maintained is the total number sent from a particular location. There is no record of subject, sender or receiver. The name, address, and telephone number of the sender appears on the hard copy received by legislators. Information office staff may suggest sending a POM to a particular committee or delegation rather than all legislators if an individual wishes to comment on a particular issue (14). Often the staff may suggest addressing a POM to local legislators as well as the committee of a particular bill (15). However, there is no restriction on sending a POM to all legislators if that is the individual's wish.

3.4 NONPARTISAN POLICY

While staff make every effort to assist people in obtaining information, a strict nonpartisan policy is maintained. This includes:

- No interpretation of legislative information

- No opinions on any legislative activity

- No writing or paraphrasing of POMs

- No summations of a legislator's activity; for instance, voting record. A person would have to search through BASIS vote by vote to compile such a record.

4. ALECSYS: USERS

Very little meaningful data exists on the citizens that make use of information offices; virtually none is available on the effect of the system on the general political behavior of the Alaskan population. In part, this is due to the fact that the system is still relatively new. It has experienced substantial growth each year of its existence. Public awareness of the system and its services seems to vary from community to community.

4.1 PUBLIC USERS

In-office public users, according to information office staff, tend to represent a cross-section of the population (16). There have been no demographic studies of users. Many nonprofit organizations make use of information offices for research purposes (17). Typically, these groups stay abreast of changes in bill status through ALECSYS. Local governments, political action committees, and corporations tend not to make use of the system -- unless they have their own ALECSYS terminal -- since these groups have access to legislators and legislative information through other sources (18).

4.2 LEGISLATIVE USERS

Just as with public users, very little has been done to measure use of the system by legislators or their attitudes toward it. There is some indication that POMs, particularly those dealing with specific subjects may be helpful to legislators in the decision making process (19). However, one former State Senator felt POMs had the same impact on legislators as telegrams and recommended personal letters as the most effective form of written communication from constituents (20). The tendency is for legislators to answer all POMs from home districts. On the other hand, POMs from outside the home district, particularly from different areas in the state may receive little or no attention (21).

As mentioned previously, all representatives and senators have a terminal in their Juneau office. Some of them are also dial-up users through their own microcomputer. In general, it tends to be legislative staff rather than the lawmakers who are familiar with ALECSYS software. Heavy use is made by legislative researchers, not only of ALECSYS but data bases maintained by the administrative branch. Similarly, state government agencies outside the legislature often access data bases in ALECSYS.

One of the most frequent user groups of ALECSYS are information office staff. In addition to BASIS and STAIRS for information retrieval, the system serves as a powerful inter-office communication link for offices spread over a 500,000 square mile state. TELE keeps offices advised of the latest teleconference schedule. EMAIL allows staff to consult with one another at will. This is often supplemented by voice communication over the dedicated teleconference circuit. However, when that circuit is busy with a teleconference, EMAIL provides a secondary channel for staff communication concerning the conference and other matters. Memos, letters, and brief notes travel between offices via EMAIL. These can be addressed to individual offices or all terminals on the system.

4.3 DIAL-UP USERS

A growing ALECSYS user group includes dial-up, non-legislative subscribers to the system. This access is available to any group, business, or individual. Subscribers must sign a users agreement and meet certain technical specifications with their terminal equipment. The subscription fee is $20.00 per month and an hourly use charge of $15.00. Programs available are BASIS, STAIRS, TELE, EDLS, HCSE, SCSE, and NEWS.

Part of the philosophy behind making portions of ALECSYS available to outside users is that the "...information maintained on this computer system may be of value not only to legislative organizations, but also to private enterprise and individuals with an interest in keeping abreast with developments taking place in the State of Alaska" (22). Bill Zyback, with the Fairbanks North Star Borough (borough is roughly the equivalent of a county in Alaska), used the terminal at the Fairbanks Legislative Information Office before the borough became a dial-up user in June of 1983. He most frequently uses STAIRS and, during the legislative session, BASIS (23).

Access to programs is controlled in two ways. First, sign-on names and passwords are assigned by data processing. Some application programs have varying degrees of security clearance. Secondly, the main ALECSYS menu for dial-up users is limited to the seven programs available to them.

Table 2

ALASKA LEGISLATIVE COMPUTER SYSTEM USERS[1]

ORGANIZATION	NUMBER OF USERS
EXECUTIVE BRANCH:	
-Office of the Governor	23
-Office of the Lt. Governor	5
-Dept. of Administration	38
-Dept. of Commerce & Economic Development	23
-Dept. of Community & Regional Affairs	4
-Dept. of Education	20
-Dept. of Environmental Conservation	3
-Dept. of Fish & Game	11
-Dept. of Health & Social Services	26
-Dept. of Labor	7
-Dept. of Law	32
-Dept. of Military Affairs	2
-Dept. of Natural Resources	21
-Dept. of Public Safety	1
-Dept. of Revenue	11
-Dept. of Transportation	52
University of Alaska	12
Legislature[2]	432
Office of Ombudsman	30
Consultants, dial-up users & lobbyists	22
Oil companies	4
Municipalities	15
Media	3
TOTAL USERS	797

1.A user is one password for access to the system.
2.Includes Legislative Affairs Agency, Legislative Information Offices, legislators and staff.
source: AK Legislative Affairs Agency, 1984

5. CONSEQUENCES

It is difficult to assess the effects of ALECSYS separate from the rest of the legislative information system. All elements in the system rely on one another to some extent. The areas ALECSYS seems to have impacted greatest are network management, access to legislative information, and citizen-legislator communication.

5.1 MANAGEMENT

From a management view, ALECSYS simplifies problems of real-time communication for such a far-flung network of offices. Staff throughout the state can be in touch with one another in a matter of seconds. Last minute changes in teleconference schedules, compilation of participation statistics following a conference, and other intra-office duties are accomplished quickly and efficiently through ALECSYS. Memoranda can travel via EMAIL to all staff or selected individuals.

ALECSYS terminals place all staff within the system on an equal footing for communication. It is as easy to send a message to the director of the system as it is to send one to any rural office. Of course, speed of response is at the discretion of the individual. The current administration of the Alaska system encourages democratic communication among offices and responds quickly to queries. The ease and speed of ALECSYS undoubtedly supports that position.

5.2 INFORMATION ACCESS

Citizen access to information concerning the legislature, previously laboriously slow and inadequate, is immediate and detailed through ALECSYS and the information offices. Any citizen can stay current, on a daily basis, with the progress of any bill. Furthermore, the citizen can research, with the assistance of information office staff, the legislative history of any issue. ALECSYS programs reduce search time to a minimum.

The ability to quickly search through ALECSYS data bases for the legislative history of statutes and regulations may be equalizing the traditional imbalance between new and veteran legislator. With the amount of data available through ALECSYS former Legislative Affairs director M.R. Charney feels freshmen legislators may not spend as much time learning the history of bills or statutes from veterans as they did ten years ago. The new legislator has as much information available as the seasoned pro (24).

Significant consequences of ALECSYS may come in the future from non-government users of the system. At this point, anyone with the proper equipment can become a subscriber to ALECSYS. With the proliferation of personal computers individuals and groups have the means to access and process the profusion of legislative information. Formerly, only those with the money for lobbyists and expensive research could benefit from a minute analysis of current and past legislative activity and computer generated trends based on that data. Dial-up ALECSYS users with a personal computer and the right software can now have access to the same types of information. While easy access to such information does not predict a major grass roots involvement in the political process, ALECSYS has opened that possibility.

5.3 CITIZEN-LEGISLATOR COMMUNICATION

ALECSYS has been used to establish, within certain limits, a private electronic mail system between legislator and legislated. Through POMs, every citizen may express his or her opinion to legislators. The population of Alaska is small enough (representatives' districts have a population of about 6,000) that it is feasible for legislators to personally respond to POMs. Between January and June of 1983, Alaskans sent 14,202 POMs to their state legislators (25). There is no record how many of those received personal responses. However, POMs can act as a barometer of public opinion, an unofficial and unscientific poll of constituent attitudes. This may be one of the primary values of the system to legislators (26).

6. PROBLEMS

Major problems to date have primarily been operational bugs. For instance, protocol problems with dial-up users and dependable telecommunication links. Most of these technical snags have been resolved. Software undergoes continual revision and addition. After six years of operation, major technical obstacles have been overcome.

Use has not yet reached the point where legislative agencies, for whom the system was developed, find themselves queued for access to a data base. Near the end of each legislative session when there is almost constant use of the system by staff, response time may be slightly slower (27). At this time, and in the foreseeable future, the number of system users are very manageable. Since a maximum of only twelve dial-ups can access ALECSYS at once, there is little problem with too many users from this sector. As this group expands there may be a need for additional entry ports.

Support for users spread over such a large area has always presented a challenge. Should the terminal in Barrow, for example, located at the northernmost tip of Alaska, go down or the local staff have operation problems, it is impossible to send someone over to that office the same day to fix things. In such cases the LTN can provide immediate, interactive communication. If it is occupied with a conference, a regular telephone call will do. Information office staff receive on-site training when possible. Dial-up users must travel to Juneau to receive training. There is a central telephone number users may call for assistance. The approach in helping users with problems is to encourage them to learn how to deal with the situation themselves, rather than doing the task for them (28). The recent formation of a users group should facilitate support.

More fundamental questions concerning the impact of ALECSYS on the legislative process in Alaska are, at this point, tentative speculations. Problems may arise simply because the Alaskan system and others like it are breaking new ground. There are no precedents on which to base policy decisions. The former executive director of the Legislative Affairs Agency feels there may be future lawsuits over ALECSYS use because it exists in a grey area of policy (29). These areas could include limiting access to data bases and using information obtained through ALECSYS for commercial purposes. A lawsuit is currently pending concerning access to the Legislative Teleconference Network.

As multiple lines of communication and faster access to greater amounts of information become realities when does the individual legislator become over saturated with input? Will a constant stream of POMs have any influence? Dave Hammock, who has worked with the legislative information system since its inception and wrote an early internal case study of its development, feels such over saturation is not a problem because legislators were already at the point of too much information before they began receiving daily POMs (30). If this is so, what impact can POMs have on a legislator? This could lead to rising frustrations among constituents, led to believe POMs provide direct communication with legislators while the response to those messages is less than anticipated.

Essentially, the type of public access to the state legislative process through ALECSYS (and the entire Alaska legislative information system) is new; therefore, it is reasonable to surmise that problems encountered may also be new. The system is too young, existing data too sparse, and trends for use of telecommunication systems and services among the general Alaskan population too vague to clearly reveal any of those issues at this point.

7. SUMMARY

In 1984 the enormous growth that has taken place with ALECSYS and the entire Alaska legislative information system has begun to level off. It is now becoming another familiar agency of state government. A generation of legislators is now serving without ever knowing a time as an elected official without benefit of the LTN and LIN. The system is in place. What remains is its slower diffusion throughout the general population. It was not intended as a vehicle to change the basic structure of the state legislature. Nor was it meant to alter the relationship of legislator to voter except to bring the two closer together. It seems, however, inevitable that changes will take place. For the moment ALECSYS, as well as the rest of the Alaska system, has demonstrated that from a technical and administrative standpoint, there are practical methods to increase participation through utilization of the new technologies of telecommunication.

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INTRODUCING ISDN IN A DECENTRALIZED NETWORK

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Introducing ISDN into an extensive decentralized area comprised of a wide variety of switching and transmission technologies presents special problems for the network planner. Utilizing the functional modules of a distributed control switching system can provide a graceful and economical means of integrating such a network.

Within the Pacific ocean area exists a unique telecommunications environment, requiring specialized techniques and system capabilities. The long distances between network points, the unusual demographics, the high cost for interexchange trunks and the unique market requirements all contribute to a major difference in planning, implementing and operating a modern integrated telecommunications network over similar sized networks encountered in other areas of the world.

While all the elements and parameters used to guide any network design are present in this area, the relative weight of circuit costs, maintenance and supervision of remote units, holding times, alternate routing and other considerations, significantly alters the traditional network solution.

The relative inaccessibility to some points, the difficulty and expense of building transmission and distribution facilities to some serving areas and the wide range of population density and market needs make this part of the world a network designer's challenge.

There are growing world wide sources of an increasingly wide range of products and systems available to serve the telecommunications market. Most of them offer genuine and reliable capabilities in some segment of network operations or services. The Pacific network could be constructed by indiscriminate application of such products on a near term "as needed" basis. As in any other part of the world, where telephone companies or administrations have different priorities and concerns, there may be too little attention paid to the longer range "one world" ISDN network. If the wide dispersal of switching elements, the long haul transmission routes, and the uncertainty of market developments make it difficult to plan an integrated network, these same conditions make it essential.

In order for a telephone company or administration to participate in the revenues from advanced communications it is necessary that they provide the advanced services. In order to stimulate modern business traffic, it is necessary for the sophisticated telecommunications infrastructure to be in place. And in order to make the network function, it is essential that "ISDN like" capabilities be added to existing network switching and transmission elements.

Of course, in many areas the conversion to modern digital switching and transmission is well under way and conventional ISDN features exist at those locations. It is also recognized that Intelsat and other transmission systems exist which provide interconnection between major communications points.

However it is likely, in many cases, that undepreciated switching systems already exist which do not have advanced ISDN features and which cannot be upgraded to include them. They may be electromechanical systems or stored program controlled machines with features limited to conventional end office analog service. In such cases, it is usually best to let these machines handle the POTS services for which they were designed and to provide most of the sophistication by the implementation of digital adjuncts specifically designed for the ISDN services.

Any modern digital switch could technically be installed to provide an ISDN capability in a wire center on a collocated office basis. However, due to the significant start-up cost of a small capacity switching complex, it is usually far too costly to consider. The cost, size and separate maintenance/administration requirements of a separate central processor complex rule out this approach in all but a very few locations.

Digital adjuncts or specific functional subsystems can be economically and technically viable in fourth generation architecture.

A fourth generation switching system is characterized by a completely distributed control structure and the absence of a central processor complex.

Each functional module is a self contained hardware/software element with its own microprocessor, program and memory. Thus, it is technically and economically feasible to assemble in as little as one frame, the functional module to provide, for instance, a common channel interoffice signaling system, a packet network access switch, or an ISDN server unit. Other functional units can also be added as required without the usual adverse effects on traffic capacity, generic software, etc. In such a switching system, the modular LSI matrix contains its own routing logic and does not depend upon instructions received from a central processor. A full 512 by 512 channel non-blocking matrix is contained on one board along with its routing and control logic. These boards may be distributed throughout the system wherever they are needed and plugged together without system reengineering or recabling.

This great flexibility and modularity permit the economical distribution of control, matrix and logic to coincide with peculiar geographic and demographic conditions in order to optimize the existing network into a modified ISDN.

It is highly desirable, although not essential, that any complex network contain a backbone common channel signaling system. This is especially true in areas such as the Pacific nations where it is very costly to occupy communications channels with slow signaling, traffic which is directed to busy stations, traffic to "hard to complete" codes, etc. In any network, a common channel signaling system facilitates the exchange of operational data, routing instructions, network management controls and service codes. If designed with reserve capacity, it may even be used for tariffed user data channels within the network or for user or telco access to large data bases. Many of the new Local Area Signaling Services (LASS) which are viewed as revenue producers require a common channel signaling system. Obviously, the cost of replacing or modifying all existing switches to interface a common channel network of signal transfer points would be prohibitive.

A viable alternative, however, can bring many of the common channel capabilities to the end office without extensive reengineering or scrapping of existing capital equipment. The fourth generation switching system contains as an element, a relatively inexpensive, stand-alone common channel signaling system of signal transfer points (STP's), mini STP's (an STP concentrator for analog offices) and satellite STP's (for remote operation).

The STP can function as a CCITT#6 or CCITT#7 terminal and/or can provide X.25 packet protocol. Depending upon the type of local or tandem exchanges, attaching the common channel signaling (CCS) modules can extend network controls to the end office, ultimately to the PBX or Centrex user. Some of the capabilities which then become available on a network basis include:

- Faster trunk signaling, more efficient use of trunk groups, better trunk administration.
- Reduction in signaling equipment, trunks become voice or DS-0 channels only.
- Elimination or reduction of incompleted calls on the network by look-ahead determination of circuit or station availability.
- "Traveling class marks" to indicate transmission parameters, priority traffic, class of traffic, etc.
- Direct access to data bases for credit card verification, mobile and marine radiophone routing, 800 services, etc.
- Direct access to packet networks.
- LASS features requiring forwarding of calling number.
- Network management, overload and catastrophe re-routing.

Another related but separate application of the fourth generation network elements is to provide ISDN capabilities in an existing lower-technology system. Around the world, data communications traffic is expanding at phenomenal rates, approaching 30% per year in some industrial nations.

For the forseeable future, this growth rate is expected to continue such that in 5 years the bandwidth dedicated to data will reach 10% of the total "long distance" bandwidth. Availability of special services such as WATS, FX, business services and Centrex are prerequisites to a growing commercial community. An essential characteristic of this changing network is the penetration of such services to the more remote wire centers as opposed to only the large urban areas with sophisticated switching and transmission systems. The evolving topology will necessarily consist of smaller, more widely dispersed data access points and ISDN service nodes, strategically distributed to serve and encourage future ISDN users.

These issues can also be addressed by a fourth generation switching product developed to provide connectivity to a broad range of Value Added Services (LAN, Data Access, etc.) that offer the administration or telco new sources of revenue while protecting their existing customer base. This is beyond the scope of the traditional central office and PBX, and provides means to achieve the following objectives:

- Increase the efficiency of loop facilities by providing concentration of centrex lines at the customer's premise.
- Position to capitalize on the many opportunities presented by the major changes occurring in the market place by cost effectively providing advanced Voice/Data and Value-added Services to selected locations on a carrier serving area basis.
- Exploit the many strengths of the existing local network by building a strong market position for ISDN business opportunities as a system vendor to end-users and to gain access to markets that might otherwise be closed or unattractive (i.e., multi-tenant operations).
- Enhance the existing business capabilities of in-place Central Office Switching systems.

A product intended to fill this current market niche of providing a method of handling the demand for new ISDN type of services on existing switching systems, economically and efficiently may be referred to as an Integrated Services Digital Network Server. The ISDN Server is designed to specifically address the features, revenue protection and growth services required for the emerging ISDNs without requiring immediate changeout or major rearrangements of existing switching systems. As the serving vehicle for voice/data access and transport services such as packet network access or Local Area Networks (LAN), the ISDN Server can be employed as a stand-alone Digital Data Network Server or positioned as an enhancement to the existing business service capabilities of in-place central office switching systems.

- The ISDN-Server consists of two elements:
  1. An ISDN Subscriber Remote Unit (SRU) that is located close to the subscriber's premise. It interfaces the subscriber loops and concentrates them onto transmission links to a Host Unit. The SRU supports 2B+D digital loops and Voice/Data subsets. It provides intercom voice services and intra-nodal data switching.
  2. The ISDN-Subscriber Host Unit (SHU) which is located at the serving Central Office. It interfaces SRU(s) and routes voice/data calls to the appropriate host facility i.e., voice calls to the Central Office, X.25 data calls to a packet network, etc.
- For switched voice message services (MTS), the ISDN Server appears as an extension of the host central office to the rest of the public network in the same manner as a subscriber carrier system. This includes number plans, transmission plan, signaling plan and interfacing to Operational Support Systems (OSS).
- The interface from the SHU to the serving central office is accomplished at the analog line side by an analog line circuit.
- The facilities between SRU and SHU may be DS-1 at T1 rates and eventually direct FTS-3 interfaces.
- For Switched Packet Data (X.25), the ISDN Server acts as a packet access/concentrator point (AC) to the Public Packet Switched Network, including (ISDN) numbering plan, synchronization and OSS's.
- The SRU can be deployed on a Carrier Serving Area (CSA) basis to enable basic call processing (call control) to be performed closer to the customer's (end-user) premise, which affords the end-user with potential

savings in loop access and facility charges. The ISDN-SRU acts as a remote switching system to a "host" central office.

- The ISDN-Subscriber Remote Unit supports 128 to 6,000 ISDN (2B+D) lines with excellent price/performance achieved across various line sizes through optimized equipment configurations.
- The ISDN-Subscriber Host Unit supports up to 50,000 (100,000 ports) users through any number of SRUs.
- The ISDN-Server (either SRU or SHU) can be upgraded to an End Office Host/Remote complex with the addition of the appropriate end office hardware and software without significant service interruptions or major rework of the existing base system.
- ISDN-Server cost of ownership can demonstrate at least 20-30% life-cycle cost savings (investment, expenses and revenues) over present modes of operation (for the same needs).

The ISDN Server provides access for X.25, LAPB, Asynchronous and Bisynchronous terminals to/from the packet network. Specifically, the ISDN-Server provides screening and concentration of terminal originated calls onto the packet network, screening and routing of terminal completed calls (both incoming from packet networks and intra-ISDN Server complex), mapping of terminal protocols (X.25, LAPB, Async, Bisync) to packet protocol (X.25), automatic congestion controls and centralized maintenance and administration. Furthermore, the ISDN Subscriber Remote Unit may be deployed on a carrier serving area (CSA) basis to provide selected customers integrated voice and data access to the network. The ISDN-Subscriber Remote Unit also supports intercom service for voice calls and local data switching for data stations in addition to providing concentrated access and transport to the ISDN Subscriber Host Unit for routing to the appropriate termination (i.e., voice calls to central office, data calls to packet networks).

This application is desirable to the telco as it unbundles the Value Added Services (packet, Simultaneous Voice and Data) from the Public Switched Network and positions the Telco to serve three primary target customers.

1. The installed terminal base. A large portion of these terminals operate in an asynchronous start-stop mode. The ISDN-Server will provide switched transport service for these terminals.
2. The growth terminal market. These terminals are either asynchronous start-stop, LAPB or X.25. The markets using growth terminals are videotext, energy/security management, small businesses, inventory control and other emerging ISDN services.
3. The administration or telco internal Data Communication needs. Telcos may find that they utilize 30-40% of the data facilities within a country to support telco operations. This alone represents a large potential customer base.

The major shortcoming of the various PBX, data processing, word processing, and other office automation systems available today is the inability to use them together. Through the use of standard interfaces for access and transport services, the ISDN-Server overcomes this shortcoming by providing connectively to a broad range of processors, services and terminals.

This application of the ISDN-Server emphasizes the concept of standard interfaces as an approach to integrate the Subscriber Remote Unit within existing office equipment rather than replacement with new proprietary equipment.

The major end user benefit with this application is that it enables the end user to access multiple processors and data services via Packet Assembly/Disassembly (PAD), Local Area Network (LAN) and network gateway communications offerings from a variety of terminals both existing and new. This provides the end-user with cost and convenience benefits which include the elimination of duplicate loops for voice and data communications, reduction of expenses associated with connecting terminals to networks, multi-function capability of terminals and elimination of separate stand-alone voice and data systems.

The objectives of this application are:

A. To integrate the ISDN-Server within the existing office environment.

B. To position the telco to take advantage of the existing network services without requiring replacement or major rearrangement of central office equipment.

The following services can be supported by the ISDN-Server for applications previously described:

A. Analog Loops

B. 2B+D Digital Loops at 144 Kb/s

C. B+D Digital Loops

D. Packet Network Access at X.25

E. Local Area Network (LAN) Gateway

F. Bulk Services (N x 64k bps)

G. Multi-tenant Operations

In conclusion, it is technically possible and economically viable to introduce ISDN capabilities and services into a widely dispersed network, providing that the architecture of the implementation system is distributed control, completely modular and has a low start-up cost.

This may be the only viable way to introduce modern voice/data communications into an exciting network such as the Pacific without prohibitive capital outlay.

Teleconferencing: Educational and Attitudinal Results With and Without Telidon

by

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BACKGROUND

While numerous studies have been done on the impact of various communications channels on users, [1] several have focused on the impact of educational teleconferencing on its users. [2] However, a search of relavant journals in the fields of education and communication showed no studies pertaining to learning and attitude difference of students who have experienced educational teleconferencing with and without Telidon - Canada's videotex system. [3]

PROBLEM

The purpose of this study was to explore the impact of educational teleconferencing on two groups of students. The impact was gauged by an academic test given to both groups and by an attitude questionnaire given to both groups. One group experienced educational teleconferencing with Telidon, while the other group had audio alone. Research questions were generated from previous research in the related areas of channel effectiveness and instructional technology. Given the exploratory nature of this study, research questions were posed rather than research hypotheses. Answering questions was of greater concern than testing hypotheses.

The research questions were:

(1) Will student test scores vary significantly from educational teleconferencing with Telidon vs. educational teleconferencing without Telidon?

(2) Will student preference to classroom lecture-discussion over educational teleconferencing vary significantly from educational teleconferencing with and without Telidon?

(3) Will student perception of the technical use of educational teleconferencing vary significantly from educational teleconferencing with and without Telidon?

(4) Will student enjoyment of educational teleconferencing as a supplement to classroom lecture-discussion vary significantly from educational teleconferencing with and without Telidon?

(5) Will student evaluation of the absence of an instructor's physical presence during educational teleconferencing vary significantly from educational teleconferencing with and without Telidon?

(6) Will student willingness to take an entire course through educational teleconferencing vary significantly from educational teleconferencing with and without Telidon?

(7) Will student reactions to educational teleconferencing with and without Telidon be favorable?

METHOD

Subjects: One hundred and twenty university students enrolled in introductory interpersonal speech communication classes in the Faculty of Education at the University of Calgary took part in the study. The study was carried out during regular class times with class groups. Each experimental session had ten subjects randomly assigned, ninety-three were female and twenty-seven were male. None of the subjects were volunteers. None of the subjects were paid. And, none of the subjects had ever experienced educational teleconferencing with or without Telidon.

Procedures: Each session lasted forty-five minutes. Two sessions per day were used alternating between sessions with and without Telidon on each day. After each session, an attitude questionnaire was submitted to each group. The questionnaire had five items with a scale for each item ranging from a low agreement score of one (1) to a high agreement score of seven (7). The questionnaire is presented in Appendix A. Each group was administered a twenty item test the following class day. One day lapsed between the educational teleconferencing session with and without Telidon and the test. The sessions covered the same information in the same order for equivalent periods of time. There were three items: each covered over a fifteen minute period of time for a total of forty-five minutes. The items included Maslow's Hierarchy of Needs, Johari's Window, and five kernel Communication Networks. The group with Telidon had these three items presented graphically in color. there were four graphics: one for the Hierarchy, one for the Window, and two for the Networks. The group without Telidon received the information pertaining to the three items via audio alone. Since class time alone was used for this study, there was enough time to submit to each group the twenty item test. Hence, the twenty item test was given to each group at the start of the next scheduled class day.

Treatment of Data: The twenty item post-test scores for the academic test were tabulated for the sixty subjects with the Telidon treatment and for the sixty subjects without Telidon. A t-test was performed on these two groups of scores. The responses to the five item post-test questionnaire were then tabulated. Because the data on the questionnaire measured different items, rather than different levels of the same item, t-tests were repeated on each item between the two groups. To determine whether or not each group had scores that clustered on any of the questionnaire and where they clustered (if they did), each item was statistically analyzed descriptively. Because of the cost factors involved in the treatment group, educational teleconferencing with Telidon technology being more expensive than without it, statistically significance was set at P .05.

RESULTS

For the twenty item academic post-test, significance was not attained : T(118) = 1.68; P = .096. However, the tendency was in the direction of significance favoring the Telidon treatment group. For the post-test questionnaire, Item I was significant and in favor of the group with Telidon: T(118) = 2.42; P = .017. Item II was not significant, but the tendency favored the group with Telidon: T(118) = 1.49; P = .140. Item III was significant for the Telidon group: T(118) = 2.11; P = .037. Item IV was significant for the Telidon group as well: T(118) = 2.56; P = .010. See Table I in Appendix B.

As for averaging the scores of each variable item on the questionnaire, the results were as follows. The results for the Telidon group will be given first, and the results for the group without Telidon will be given second. Each will be given according to questionnaire items. For Item I with Telidon, the mean = 4.200, median = 4.269, mode = 5, range = 6, standard deviation (SD) = 1.655, and skewness = -.075. For Item II with Telidon, the mean = 3.233, median = 2.912, mode = 3, range = 6, SD = 1.681, and skewness = .681. For Item III with Telidon, the mean = 5.183, median = 5.182, mode = 5, range = 4, SD = 1.127, and skewness = -.154. For Item IV with Telidon, the mean = 4.433, median = 4.571, mode = 4, range = 6, SD = 1.166, and skewness = -407. And for Iten V with Telidon, the mean = 4.683, median = 4.889, mode = 5, range = 6, SD = 1.490, and skewness = -.608. See Table II in Appendix B.

For Item I without Telidon, the mean = 4.883, median = 5, mode = 5, range = 6, SD = 1.427, and skewness = -.512. For Item II without Telidon, the mean = 2.817, median = 2.711, mode = 3, range = 6, SD = 1.372, and skewness = .913.

For Item III without Telidon, the mean = 4.700, median = 4.850, mode = 5, range = 5, SD = 1.369, and skewness = -.334. For Item IV without Telidon, the mean = 5.117, median = 5.208, mode = 5, range = 6, SD = 1.236, and skewness = -1.008. And for Item V without Telidon, teh mean = 3.933, median = 4, mode = 4, range = 6, SD = 1.625, and skewness = -.036. See Table III in Appendix B.

DISCUSSION

The results from the descriptive statistics for the groups with and without Telidon suggest a slight preference for classroom lecture-discussion over educational teleconferencing on Item I. The results both groups indicate that neither thought that educational teleconferencing was too technically complicated on Item II. Both groups suggest the educational teleconferencing as a supplement to classroom lecture-discussion was enjoyable on Item III. Both suggest that the absence of an instructor's physical presence troubled them slightly, although less trouble was indicated by the group with Telidon than by the group without Telidon. Finally, the descriptive statistics indicate that the Telidon group would favor (although slightly) taking an entire course via educational teleconference, while the group without Telidon statistically suggests that they would be marginally interested in taking such a course. Overall, both groups tended to be favorably disposed toward educational teleconferencing whether they were in the group with Telidon or the groups without Telidon.

The results from the t-tests of the questionnaire items favor the educational experience with Telidon over that without it. Since both groups were merely told they would be having a class via educational teleconference and since neither group was told there would be a difference in the technology of the educational teleconference, both responded to the generic notion of educational teleconferencing rather than educational teleconferencing with or without Telidon. This, perhaps, increases confidence in the results that favor the use of Telidon in the educational teleconference. However, since the instructor and the experimenter were the same, the contamination of demand characteristics from the experimenter may have entered. While the experimenter admits a favorable leaning toward both conditions of the technology experimented with, he acknowledges a clear and present bias in favor of the Telidon for telelecturing, if not for seminar discussions.

He is presently confident that regardless of the instructor's bias, students will respond more favorably to educational teleconferencing with Telidon than without it. Perhaps, what Taube (1961:77-78) states about computers applies here especially to the relation of Telidon to its users: "machines can convert an environment in which the brain cannot function into one in which it can function." We might at least say that Telidon can convert an environment in which the brain functions to a low degree into one in which it functions to a high degree.

As for the results obtained from the t-test run on the different scores the two groups had on the twenty item academic test, the statistically insignificant results might be explained in several ways. Since the treatment occurred on a Tuesday uniformly and the test was given on a Thursday uniformly, what happened in between is open to question. Perhaps, the Telidon group did not study as long as the group without Telidon. This was not checked. Maybe, both groups studied toward a grade rather than in light of the educational teleconference. Or, it might have been the case that the members of one group did not study as thoroughly as the other group. However, since none of this was investigated, it must for now be speculation.

Several other intervening factors should be mentioned. These, too, might have had adverse effects on the results. The grand majority of the subjects were female, and all the subjects were education majors facing a tight teachers' market. These factors may hide relevant information and thereby distort the results. Another factor that could feasibly modify the results we found is the teaching mode. If a seminar at the graduate level were conducted via teleconference, there may be minimal benefit derived from the use of Telidon. However, since the Telidon group scored higher than the groups without Telidon, we might speculate that fatigue took its toll in the lecture-discussion format used in the present study. The forced attention required of the groups without Telidon might have exhausted the students sooner than they would have been in a seminar format with discussion only and no lecturing. Finally, the scaling instrument used in this study was not tested thoroughly before being used. If finer results are desired, then a scaling instrument tested thoroughly in terms of validity and reliability might modify the results found in this study. It would likely refine the results at minimum.

CONCLUSIONS

The findings of this study suggest, of course, that given the exploratory and general nature of this study, additional research is necessary to refine the techniques and procedures used in this study. Yet, the results found in this study are consistent with the educational findings of Black (1981), Puzzuoli (1970), and Arndt and Weinswig (1974). The attitude results found in this study are consistent with those of Gartrell and Mendenhall (1975), Nasser and McEwen (1976), Arlen (1981), and Short (1974). For further research, greater controls will be needed as well as greater precision in measuring the dependent variables along with more sophisticated statistical treatment of the data.

As regards the research questions posed for this study, in light of the prededing qualifications, the following conclusions are supported:

(1) Although statistical significance was not attained, educational teleconferencing with Telidon should have greater educational value than educational teleconferencing without Telidon.

(2) Even when students prefer classroon levture-discussion to educational teleconferencing, they are likely to prefer educational teleconferencing with Telidon than without it.

(3) Students are not likely to react to educational teleconferencing as being too technically complicated to learn from, regardless of the presence or absence of Telidon.

(4) As a supplement to classroom lecture-discussion, students are likely to appreciate educational teleconferencing - but more so with than without Telidon.

(5) Although the physical absence of an instructor is likely to trouble students taking part in an educational teleconference, those without Telidon are likely to experience more trouble than those with it.

(6) While students tend to be willing to take an entire course via educational teleconference, the course offering Telidon with the educational teleconference would likely be preferred to that without it.

(7) Whether students are taking a class through educational teleconference with Telidon or without Telidon, although they tend to prefer the classroom lecture-discussion over the education teleconference, they are likely to have an open and positive attitude toward educational teleconferencing.

In sum, these answers suggest questions to be answered more thoroughly by future researchers - questions not even considered in this study.

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NOTES

1. These include the articles by Dunathan and Powers, Arlen Arndt and Wenswig, Ball and Bochmann and Gecsei, Ball and Gecsei, McLuhan and Powers, Parkhill, Phillips, Plakias, Short, Tompa and Bochmann and Gecsei, Winn, Dwyer, and Harrison.

2. These include the articles by Baratt, Jeffery, Black, Gartrell and Menhall, Hanaberg, Masser and McEwen, Orton, and Puzzuoli.

3. These include the bibilographies by Simonson, Thies, and Burch, the overview and projections by Singh, the Canadian report of the Clyne Commission, the Swedish report of the Commission on New Information Technology, and the references by Godfrey and Chang.

APPENDIX A

Circle the item which best describes your response to the following statement:

Low Agreement With Statement	High Agreement With Statement

I. I prefer classroom lecture-discussion to educational teleconferencing.

_1_ _2_ _3_ _4_ _5_ _6_ _7_

II. Educational teleconferencing was too technically complicated to learn from.

_1_ _2_ _3_ _4_ _5_ _6_ _7_

III. I enjoyed educational teleconferencing as a supplement to classroom lecture-discussion.

_1_ _2_ _3_ _4_ _5_ _6_ _7_

IV. The absence of an instructor's physical presence during educational teleconferencing troubled me.

_1_ _2_ _3_ _4_ _5_ _6_ _7_

V. I would be willing to take an entire course through educational teleconferencing.

_1_ _2_ _3_ _4_ _5_ _6_ _7_

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APPENDIX B

TABLE I

POST-TEST SCORES QUESTIONNAIRE FOR TELIDON AND NOT TELIDON GROUPS

	T (118) =	P =
Item I*	2.42	.017
Item II	1.49	.140
Item III*	2.11	.037
Item IV*	2.56	.012
ITEM V*	2.64	.010

* Significance for Telidon Groups

TABLE II

AVERAGING SCORES FOR TELIDON GROUPS

	Mean	Median	Mode	Range	SD	Skewness
Item I	4.200	4.269	5	6	1.655	-.075
Item II	3.233	2.912	3	6	1.681	.681
Item III	5.183	5.182	5	4	1.127	-.154
Item IV	4.433	4.571	4	6	1.661	-.407
Item V	4.683	4.889	5	6	1.490	-.608

TABLE III

AVERAGING SCORES FOR GROUP WITHOUT TELIDON

	Mean	Median	Mode	Range	SD	Skewness
Item I	4.883	5	5	6	1.427	-.512
Item II	2.817	2.711	3	6	1.372	.913
Item III	4.700	4.850	5	5	1.369	-.334
Item IV	5.117	5.208	5	6	1.236	-1.008
Item V	3.933	4	4	6	1.625	-.036

FRAME SYNCHRONIZATION FOR DIGITAL FIBER OPTIC COMMUNICATIONS

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Abstract

The problem of locating a periodically inserted frame synchronization pattern in random data is considered for a direct-detection fiber optic communication channel. Both pulse-position modulation and on-off keying with known symbol synchronization are considered. The high signal-to-noise ratio approximation of the maximum likelihood decision rule is derived for each of these cases. Analytical bounds and simulation results on synchronization probability show that the high SNR ML rule has a performance approaching that of the optimum ML rule over a wide range of signal-to-noise ratios. This decision rule also provides a substantial performance improvement over the correlator rule with virtually no additional implementation complexity.

I. INTRODUCTION

Fiber-optic channels are emerging as a dominant technology in line communications. They will play a major role in the digital communication systems implemented in the 1990s. This paper addresses the frame synchronization problem for these communication systems. Frame synchronization is usually required in many diverse applications such as TDM, computer communications, and image transmission. Easily implementable and nearly optimum synchronization techniques are derived in this paper.

II. MAXIMUM LIKELIHOOD FRAME SYNCHRONIZATION

We consider a direct-detection fiber optical communication system in which data transmission is formatted in successive frames. Each frame consists of N data symbols S_1, S_2, ..., S_L d_{L+1} ..., d_N where the first L symbols S_1, S_2,..., S_L is a fixed frame-synchronization sequence and the remaining N-L symbols $d_{L+1}, \ldots, d_N$ are random data. No restriction on the random data to preclude the presence of the frame-synchronization pattern in the data symbols is made. Two types of modulation formats, Q-ary PPM and OOK, are considered. Both signaling schemes are widely used. In Q-ary PPM, a one-to-one correspondence between each Q-ary symbol and Q equal time slot divisions of the symbol period is used to send a rectangular light pulse in the time slot associated with the symbol to be transmitted. In OOK, binary data symbols are sent by the presence or absence of a light pulse during the symbol period. The output of the direct-detection optical channel given the data sequence sent is a conditionally Poisson process with intensity rate equal to $\lambda_s + \lambda_n$ photons/second when a light pulse is transmitted and λ_n photons/second otherwise. Here λ_s models the photodetector output count rate due to the light pulse and λ_n the count rate due to dark current.

We shall assume here that symbol synchronization has been achieved. That is, the symbol time boundaries are known. This implies also that the slot time boundaries are known for the PPM case. The problem we shall consider is to estimate the frame boundary position given an arbitrary segment of channel output observations corresponding to N transmitted symbols. It can be shown that the sufficient statistics for this problem are the sequence of photon counts in the NQ(N) slot times (symbol times) in the PPM (OOK) case. For PPM (OOK), let

$$\underline{K} = (K_1, K_2, \ldots., K_N)$$

be the QN-vector (N-vector) of counts corresponding to an arbitrary span of N channel input symbols. For PPM, $K_i = (K_{i1}, \ldots, K_{iQ})$ are the counts corresponding to the Q slots of the i-th symbol and for OOK K_i is the count corresponding to the i-th symbol. The frame synchronization problem is to determine $\hat{m}$, $0 \leq \hat{m} \leq N-1$, to maximize the likelihood that $(K_{\hat{m}+1}, K_{\hat{m}+2}, \ldots K_{\hat{m}+L})$ are the counts corresponding to the frame synchronization pattern $(S_1, \ldots, S_L)$. (The indices are interpreted modulo-N to accommodate periodic frame boundaries). The maximum likelihood approach maximizes synchronization detection probability since it is reasonable to assume the frame boundary positions are a priori equally likely. In the PPM case, the NQ components of $\underline{K}$ are conditionally independent Poisson random variables given the N-L random data symbols, with parameter $(\lambda_s + \lambda_n)T'$ for the light pulse slots and $\lambda_n T'$ otherwise, where T' is the slot duration. For OOK, the N components of $\underline{K}$ are also conditionally independent Poisson random variables given the random data, with parameters $(\lambda_s + \lambda_n)T_s$ when a light pulse is sent and $\lambda_n T_s$ otherwise, where T_s is the symbol period.

Georghiades and Snyder [1] derived the following maximum likelihood rules to estimate m:

ML Estimate of $\hat{m}$ forQ-ary PPM

Given the count vector $\underline{K}$, $\hat{m}$ is the value of m in [0, 1,...N-1] that maximizes

$$L_{PPM}(m) = \ln(x) \sum_{i=1}^{L} \bar{K}_{i+m} - \sum_{i=1}^{L} \ln \left[\sum_{j=1}^{Q} x^{K_{i+m,j}} \right] \quad (1)$$

where $x = 1+\lambda_s/\lambda_n$ and $\bar{K}_{i+m}$ is the component of K_{i+m} whose slot position corresponds to the pulse slot of the i-th symbol in the frame-synchronization sequence.

ML Estimate of $\hat{m}$ for OOK

In this case $\hat{m}$ is the value of m maximizing

$$L_{OOK}(m) = \ln(x) \sum_{i=1}^{L} \bar{K}_{i+m} - \sum_{i=1}^{L} \ln \left(1 + e^{-\lambda_s T_s} x^{K_{i+m}} \right) \quad (2)$$

where $\bar{K}_{i+m} = K_{i+m}$ if the i-th symbol in the frame-synchronization sequence corresponds to the transmission of a light pulse and $\bar{K}_{i+m} = 0$ otherwise.

The commonly used and much more easily implementable correlation decision rule is to choose $\hat{m}$ to maximize

$$L(m) = \sum_{i=1}^{L} \bar{K}_{i+m} \quad (3)$$

for both PPM and OOK. Note that both (1) and (2) require the knowledge of the photodetector output SNR λ_s/λ_n and in addition (2) requires the knowledge of the detected signal photon count rate λ_s. Since these quantities may not be accurately determined in practice, the ML rules (1) and (2) may be much more difficult to implement than the correlator rule (3). We also note that (3) does not require the nonlinear function evaluations in (2) and (3). The correlator rule thus has significant implementation advantage over the ML rule for both PPM and OOK.

III. HIGH SNR RULES

A. PPM Modulation

We are motivated by Nielsen's work [2] to consider the form of the ML frame synchronization rule (1) in the limit of large SNR λ_s/λ_n. In this situation the sum $\sum_{j=1}^{Q} x^{K_{i+m,j}}$ can be replaced by $x^{\tilde{K}_{i+m}}$ in (1), where

$$\tilde{K}_{i+m} = \max_{1 \le j \le Q} \left| K_{i+m,j} \right| \quad (4)$$

is the maximum count among the Q slots in the (i+m)-th symbol. This results in a decision rule where m is chosen to maximize

$$L_{HPPM}(m) = \sum_{i=1}^{L} \left[(\bar{K}_{i+m} - \tilde{K}_{i+m}) \right] \quad (5)$$

We shall refer to this as the high SNR ML rule. This decision rule does not suffer from the implementation drawbacks of the ML rule (1) mentioned previously. It is, in fact, virtually as simple to implement as the correlator rule (3).

It is interesting to compare the performance of the suboptimum high SNR ML rule (5) to that of the optimum ML rule and also to that of the commonly used correlator rule. Unfortunately, it appears that an exact analytical evaluation of the synchronization probability is not generally tractable for these rules.

Since exact performance evaluation does not appear to be possible, an alternate approach is to determine meaningful upper and lower bounds on synchronization probability. A union lower bound on synchronization probability for the correlator rule is derived. A union lower bound on synchronization probability for the high SNR ML rule in the quantum limited optical channel ($\lambda_n = 0$) case is also derived. The optimum ML rule unfortunately did not yield to a union bound analysis. Deviations of these bounds are given in [3].

Synchronization performance is dictated not only by channel noise but also random data. The fact that the frame-synchronization sequence can be replicated in certain sequences of the random data sequence ensemble implies that false synchronization on data can occur even when the channel is noiseless. Thus synchronization probability is upper bounded by the optimum synchronization probability for the noiseless channel. We call this the random-data-limited upper bound P_{RDL} on synchronization probability. This upper bound applies to all decision rules. Nielsen [2] has determined P_{RDL} for the binary data symbol case under the assumption that no prefix of the synchronization pattern is also a suffix of that pattern. It can be shown [3] that the generalization of Nielsen's derivation to Q-ary data symbols is given by

$$P_{RDL} = \sum_{i=0}^{M} \frac{(-1)^i}{1+i} \binom{N-L-(L-1)i}{i} Q^{-Li} \quad (6)$$

where the same restriction on the synchronization pattern as in [2] applies.

Computer simulations were also performed to assess both the performance of the three decision rules considered in this paper, and the tightness of the derived analytical bounds on synchronization probability. Computer simulations on the ML, the high SNR ML, and the correlator rules were conducted for both the quantum-limited optical channel and the optical channel with a noise count of $\lambda_n T'=4$ photons per PPM time slot. Simulation results on synchronization probability, together with evaluations of the union lower bounds and the random data limited upper bounds, are shown in Figures 1A and B, 2A and B, 3A and B, respectively, for the cases (N, L, Q) = (4, 2, 2), (8, 2, 4), and (12, 2, 8). Over a range of signal counts $\lambda_s T'$ per PPM slot from 2 to 16, we observe that performances of the high SNR ML rule are within a fraction of a dB from that of the optimum ML rule, whereas performances of the correlator rule degrade from that of the ML performance by as much as 6 dB for the quantum-limited channel and as much as 3 dB for the noisy channel.

For the quantum-limited channel, we also observe that the union lower bound of the high SNR ML rule is much tighter than its counterpart for the correlator rule. Consequently, the union lower bound generally provides a more accurate performance estimate for the high SNR ML rule than that for the correlator rule, although both bounds are asymptotically tight for large signal counts.

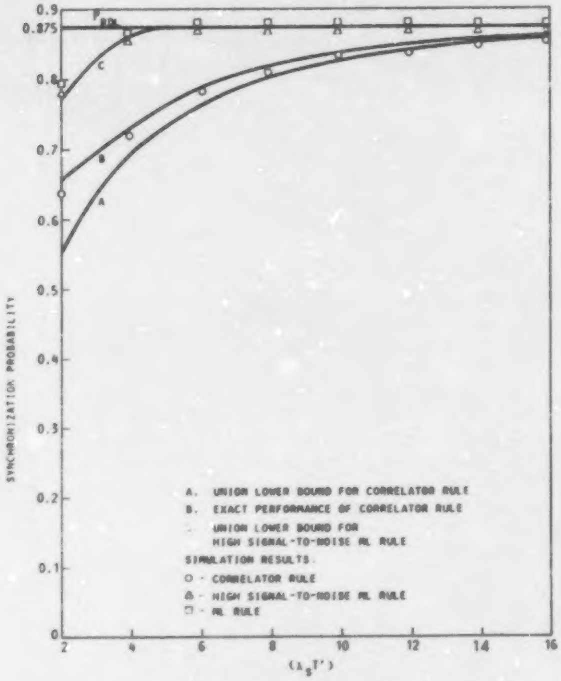

FIGURE 1A. PERFORMANCES OF PPM SYNCHRONIZERS FOR N=4, L=2, Q=2, $\lambda_n T'=0$

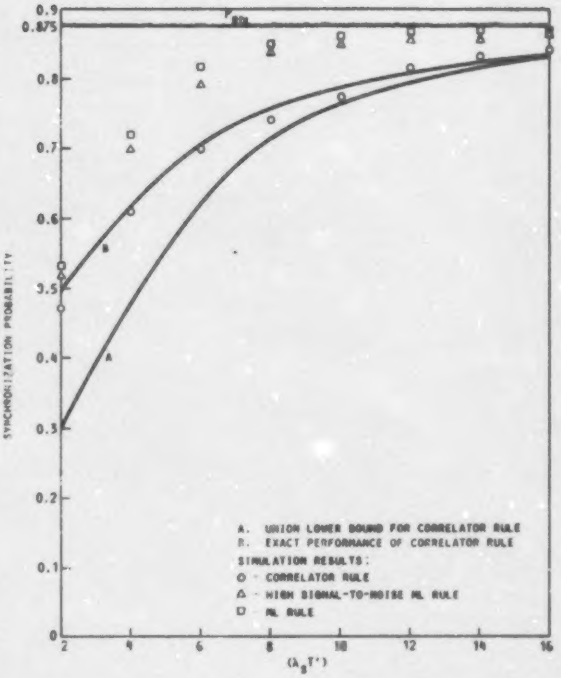

FIGURE 1B. PERFORMANCES OF PPM SYNCHRONIZERS FOR N=4, L=2, Q=2, $\lambda_n T'=4$

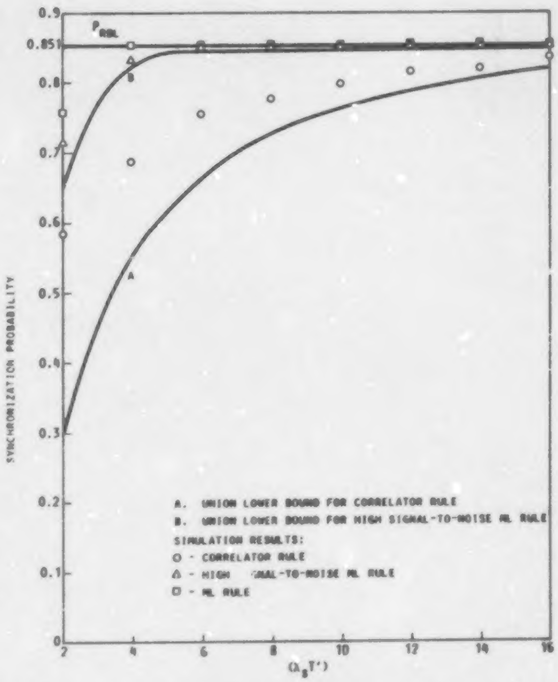

FIGURE 2A. PERFORMANCES OF PPM SYNCHRONIZERS FOR N=8, L=2, Q=4, $\lambda_n T'=0$

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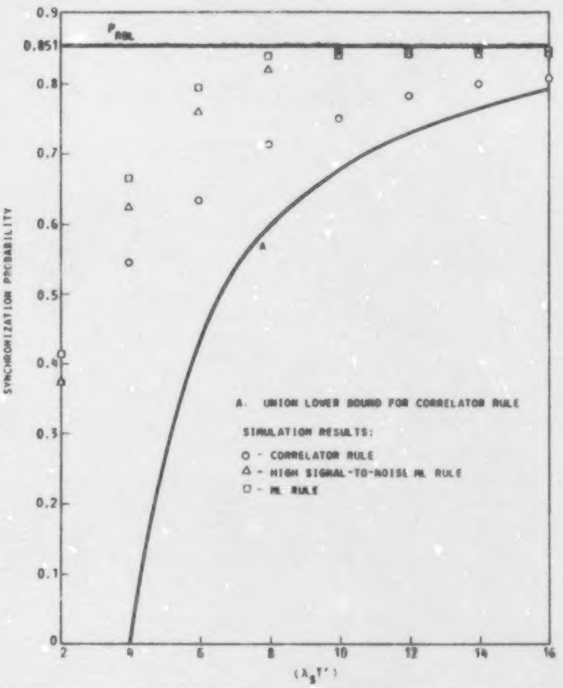

FIGURE 2B. PERFORMANCES OF PPM SYNCHRONIZERS FOR N=8, L=2, Q=4, $\lambda_n T'=4$

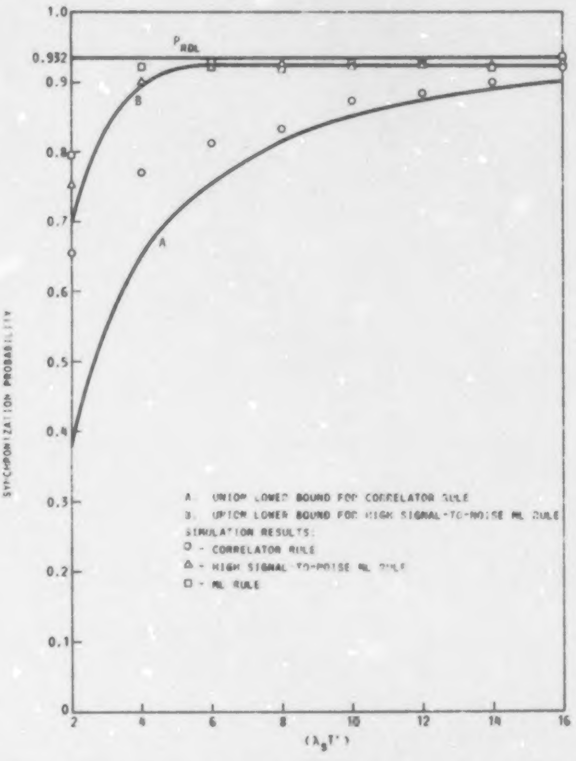

FIGURE 3A. PERFORMANCES OF PPM SYNCHRONIZERS FOR N=12, L=2, Q=8, $\lambda_n T'=0$

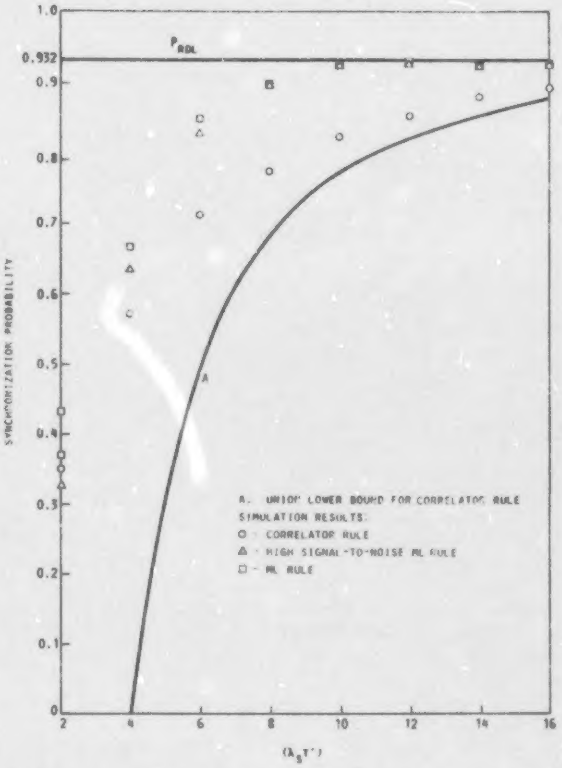

FIGURE 3B. PERFORMANCES OF PPM SYNCHRONIZERS FOR N=12, L=2, Q=8, $\lambda_n T'=4$

B. OOK Modulation

We now consider the ML rule for OOK in the limit of large SNR λ_s/λ_n. Consider the nonlinear term $\ln\left[1+e^{-\lambda_s T_s} x^{K_{i+m}}\right]$ in (2). For a fixed λ_n and λ_s sufficiently large, this term is approximately 0 for data symbol $d_{i+m}=0$ or approximately $K_{i+m}\ln(x) - \lambda_s T_s$ for data symbol $d_{i+m}=1$. Since d_{i+m} is equally likely to be either 0 or 1, we will approximate this nonlinear term by $\frac{1}{2}\ln(x)K_{i+m}$. With this approximation in the ML rule, the resulting high SNR ML rule is to maximize over m

$$L_{HOOK}(m) = \sum_{i=1}^{L}\left[\bar{K}_{i+m} - \frac{1}{2}K_{i+m}\right] \tag{7}$$

As in the PPM case, this high SNR ML rule (7) does not have the implementation drawbacks of the optimal ML rule (2) mentioned before. It is as simple to implement as the correlator rule (3).

As in the PPM case, exact synchronization probability evaluations for the ML rule and the high signal SNR ML rule are generally intractable. So union lower bounds on synchronization probability for both the correlator rule and the high SNR ML rule are derived [3] to aid in performance evaluation. The random-data-limited upper bound (6) for the case Q = 2 applies here.

Computer simulation results on synchronization probability for the ML rule, the high SNR ML rule, and the correlator rule, together with evaluations of the random-data-limited upper bound were obtained for case N=4, L=2, sync pattern=01, and case N=28, L=7, sync pattern=1110010. The latter sync pattern is a 7-bit Barker sequence. The union lower bounds for the correlator and high SNR ML rules were also evaluated in these cases. Figures 4A and B and 5A and B show these results for both the quantum-limited channel and the noisy channel. Here the performance improvement of the high SNR ML rule over that of the correlator rule is indeed noteworthy. Whereas performance of both the ML and high SNR ML rules tend to the random-data-limited performance bound, P_{RDL}, for large signal counts, the performance of the correlator rule rapidly presaturates to a level P_s which is substantially below P_{RDL}. For example, P_{RDL} = 0.875 and $P_s \simeq 0.59$ for case N=4, L=2 and P_{RDL} =0.942, $P_s \simeq 0.54$ for case N=28, L=7. That presaturation arises for the OOK correlator rule is seen from the fact that the zeroes of the frame-synchronization pattern effectively increase the number of replicated frame-synchronization patterns among the random data sequences and hence greatly degrade correlator performance. For example, in the absence of channel quantum noise, the symbol patterns 1100111, 1101111, 1110111, and 1111111 are regarded by the correlator rule as being identical to the frame synchronization pattern 1100111. In this instance, a post-detection correlator may yield better performance improvement than the predetection correlator rule studied here. It remains an interesting problem to analytically determine P_s for general N, L and synchronization patterns.

IV. CONCLUSIONS

The high signal-to-noise ratio approximate ML rule is derived in this paper for both PPM and OOK signaling over the direct-detection fiber optical communication channel. Simulation results and analytical performance bounds were presented which show that the high SNR ML rule for this channel provides significant performance improvement over the correlator rule. In fact, the performance of the suboptimal high SNR ML rule is virtually the same as that of the optimum ML rule over a wide range of usable signal-to-noise ratios. Yet instrumentation of the high SNR ML rule is almost as simple as the commonly used correlator rule. It appears to be the most attractive decision rule to use in these frame synchronization problems.

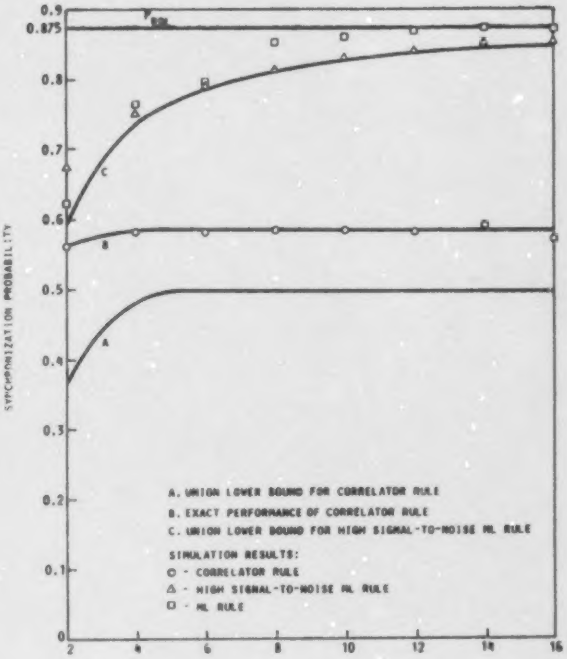

FIGURE 4A. SYNCHRONIZER PERFORMANCES FOR N=4, L=2, $\lambda_n T'=0$, SYNC PATTERN = 01

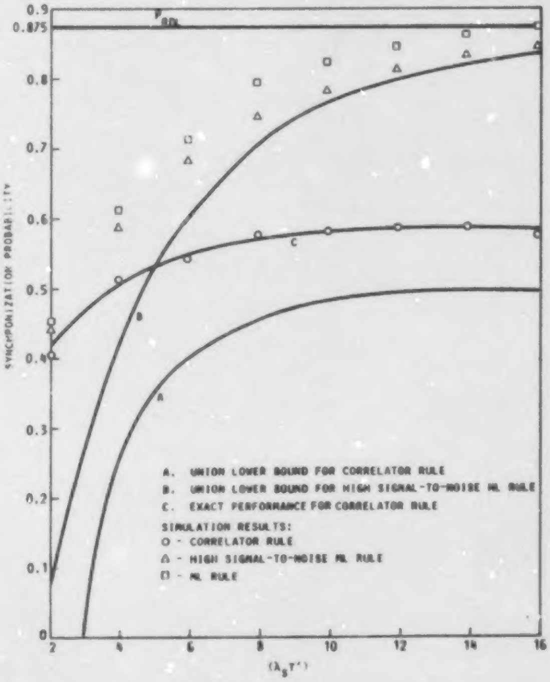

FIGURE 4B. SYNCHRONIZER PERFORMANCES FOR N=4, L=2, SYNC PATTERN = 01, $\lambda_n T'=4$

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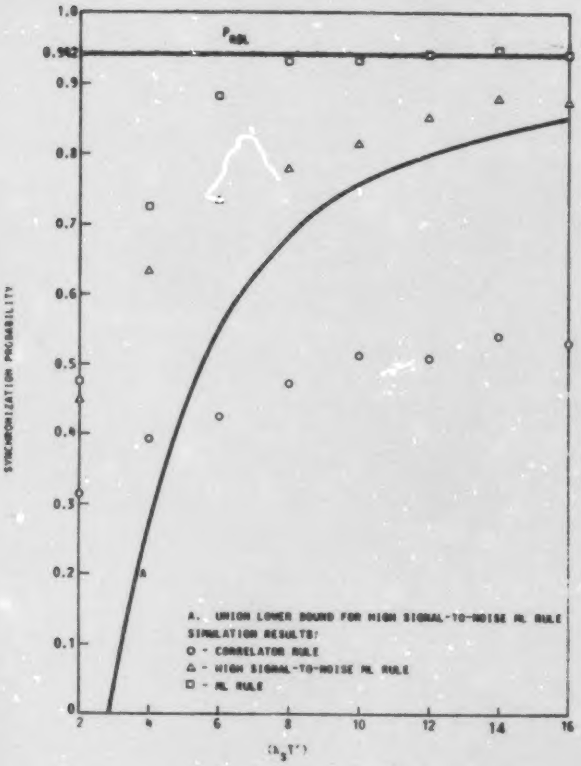

FIGURE 5A. SYNCHRONIZER PERFORMANCES FOR N=28, L=7, SYNC PATTERN = 1110010, $\lambda_n T'=0$

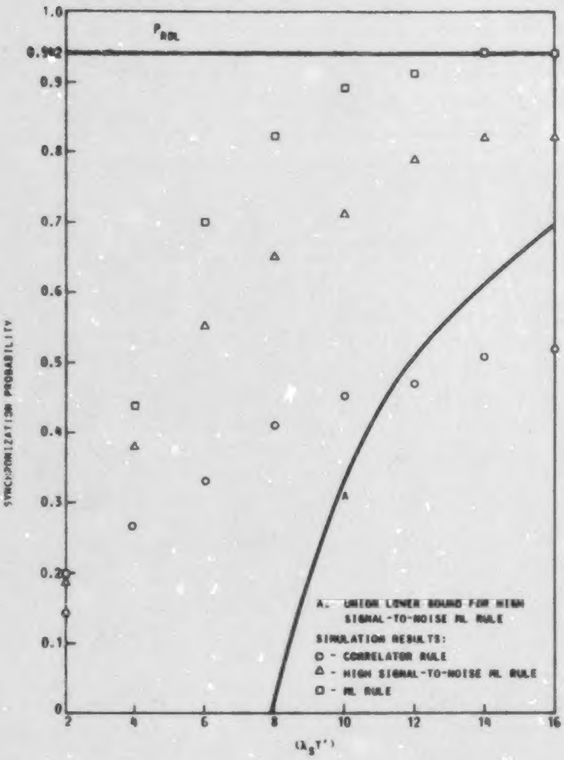

FIGURE 5B. SYNCHRONIZER PERFORMANCES FOR N=28, L=7, SYNC PATTERN = 1110010, $\lambda_n T'=4$

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TELE-CYBERNETICS: DIGITAL IMPLICATIONS

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1. *Abstract*

Tele-cybernetics was etymologically derived and explained in our paper, "Tele-cybernetics: Today's Challenge," published (1) in PTC '81: Tele-cybernetics means political science in our Age of Tele-communications, as would have been derived from Plato and, in 1834, by the electrical scientist, Ampère (2). The term could also be viewed (despite the rather inept derivation of 'cybernetics' by electrical engineer, N. Wiener (1948)) as: tele-communications plus tele-control (i.e., *proper* tele-controls). Thus, the present paper actually centers on tele-communications *policy*, particularly as that policy is affected by the increasingly widespread utilization of digital tele-communications. What are the proper tele-controls necessary to ensure that reason will prevail in our Age of Tele-communications?

2. INTRODUCTION

We note in this paper the unwariness of our arrival, this century, into our Age of Tele-communications from the preceding Age of Written/Printed Communications with its concomitant Age of Enlightened Reason. Earlier we (1,4) placed human communications in the historical perspective, revealing thereby that we have overlooked the pertinence of *controls* in and on inter-human communications, controls which ensure the prevalence of both the rationality of discussions and their ensuing conclusions.

Even the popular press has recently become more and more aware that we have failed to institute proper controls, even tele-controls, over tele-communicative media. For example, the British journal, *The Economist*, has noted [08.IX.1984: p. 72] the illicit counterfeiting (copying) of computer programmes, even those which are digitally transmitted electronically or accessed via tele-processing. Similarly, Seller has noted (5) that the Australians are instituting copyright laws for software (computer programmes), a control mechanism suggested earlier (1,4).

As another example, the American judiciary [*New York Times*, 21.IX.1984: p. A19] has opted to ban television cameras from Federal courts. The Judicial Conference of the United States has ruled that the "alleged public benefits [of television coverage] are outweighed by the risks to the administration of justice." Are these judicial controls proper? necessary?

Historians and archivists also have become "worried" [*New York Times*, 26.VIII.1984, p. 1] because the drafts of Presidential speeches, now being prepared largely on word processors, are no longer being preserved as were the written drafts of earlier White House speech-writers. Will paper copies of these processor-produced drafts be required or will electronic recordings of each draft be maintained? What standards are being applied for the recording of these digital communications? How will such electronically recorded "documents" be stored archivally (5)?

The reported "fusion" of telephone and computers, such as the Rolm Corporation's Mesquite [*New York Times*, 18.IX.1984: p. D27], will produce "voice-data" work stations. Will these be equipped to provide, via the National Bureau of Standards' time synchronization service, a continual Greenwich Mean Time *and* geographic location (i.e., telephone number, minimally) of each transmission? Will not an "electronic postmark" need become standard operating procedure, particularly for international, inter-continental, and even global voice-data electronic transmissions?

Even voice telephonic transmissions are increasingly being digitised (6), the encoded signals, or pulses, being devoiced from the analog waveform of the source of the transmission. An immediate "control" mechanism becomes evident: viz., encryption, providing for this electronic mail system the long-established notion of the "sealdd letter." Marshall's technological discussion (7) of the principles of digital communications will become particularly more important as the usage of fibre optics increases.

The telegraph, among the telecommunicative media, was itself inherently digital. The widespred digitisation of telephony is merely leading to an increased awareness (1,4) for tele-cybernetics: political science in our Age of Tele-communications, i.e., for tele-communications plus (proper) tele-controls.

3. THE HISTORICAL PERSPECTIVE

Now that digital telephony, including transmissions by fibre optics, has become rather commonplace, we are beginning to become more aware that we had indeed overlooked the matter of establishing proper controls, even tele-controls, in our tele-communication systems. The advent of widespread personal computers, connected via modems to the telephone system for the transmission of digital communications, has led to "electronic break-ins" and to the theft of information "magnetically filed" on computer-accessible disks and tapes miles distant from the computer terminal. Where is, by analogy, the control ("electronic locks" and even laws) which usually successfully inhibit the illicitly behaved hacker from entering the "electronic file cabinet" of magnetically recorded material?

A near tragic oversight in establishing proper tele-controls becomes evident in the current national or international antics of terrorists. What has one gained by receiving a completely anonymous call from an individual claiming that his group is taking credit for the bomb which either has just been exploded or will soon be detonated? Was it he or his adversaries who planted the bomb? By analogy with the postal system of the Age of Written/Printed Communications, where is the "electronic postmark" which would provide considerable information regarding the time and location of the individual(s) who are claiming credit for the terror? Indeed, would not this "electronic postmark", if adopted as standard operating procedure for all (digitally equipped) telephonic-transmissions, also curtail considerably the clandestine activities among computer hackers?

In our earlier paper (1), we presented the evolution of inter-human communications in the historical perspective. As a summary of those results, we present here three tabulations of this evolution.

In the first (Table I) are revealed the three forms of inter-human communications.

TABLE I

Styles of Inter-human Communications

Style/Purpose	Example
Person-to-person	Letter
Social	Theater
Archival	Book

One should note that the archival style, designed to be stored in a museum or a library, is actually a form of social communication, though any of its authors' purposes is to orient his artwork to future generations rather than just contemporaries.

These archival communicative media have themselves evolved. As Ben Franklin himself has noted (4; p. 15), Man is the tool-making animal; our tools' most pertinent advantage is in their use to build models so as to transmit from generation to generation our accumulated knowledge of the world about us. Table II delineates this progressive evolution of the models of man, revealing that our ancestors first constructed material (physical) models, then literal models, the latter requiring both a writing instrument (as the tool) and a grammatical control for its precision.

TABLE II

Progressive Evolution of the Models of Man

Modelling Format	Examples	Language
Physical	Statue, Painting	Hieroglyphic
Literal	Description	Natural (First-person)
	Formalisation	Mathematico-logical (Third-person)
	Simulation	Computer-directed (Second-person)

The final column of Table II lists parenthetically the grammatical character of alternative linguistic artforms, particularly pertinent in describing the differences among these forms as they are employed by scientists devoted to the augmentation of Human Knowledge.

The natural evolution of human language has developed from oral communications, then to hieroglyphics, and more recently to written (particularly, the phoneme-derived) natural languages, then to the more concise language of mathematics. This historical progression was outlined in the literature (8) of computing, it being noted that the advent of printing provided both for the wider dissemination of the models of previous generations and for their storage in national museums. The use of archival repositories has proved to favour the survival of those nations who could ensure the progressive evolution of the archives via their best minds.

Yet, in the past century, Man has applied his knowledge of electricity and magnetism to provide tele-communications. The final entry ('Simulation') of Table II's 'Examples' reflects this evolution if one notes that the author of a computer programme (which is an algorithmic simulation of something or of some process) writes a second-person communication which can be transmitted to the robot (the computer) telegraphically. Thus, the evolution of Man's model-building (cf. Table II) is quite compatible with the evolution of his communications (cf. Table III), a result in consonance with the entries in Table I itself.

TABLE III

Evolution of Human Communications

Communicative Medium	Modelling Format
Oral	Physical/Descriptive
Written/Printed	Description/Mathematics
Tele-communicative	Computerised simulation

The pertinence of tele-communications to the rapid dissemination, scrutinisation, & confirmation of a systemic scientist's computer-directed model has also been indicated in the literature (9).

However, the recent evolution of human communications can be viewed as a devolution; widespread tele-communications returns Man to oral (ambiguous, hastily-prepared, ill-remembered) rather than to written (precise and permanently recorded) communications (1,4). What methods of "tele-controls" must we undertake so as to ensure honest, reliable tele-communications? Shall we let Table III be read vertically as the dawn (oral), the day (written/printed), and the dusk (tele-communicative) of Human Reason?

4. CONTROL IN COMMUNICATIONS

Reason can be shown historically to be founded on the proper *control* of human communications, particularly written communications, whether prepared by hand and transmitted via the post or published by press and disseminated to individuals and archives (1).

The essence of *any* political system is indeed social communication and its control. In this context, "tele-control" is to be of paramount concern as the political implications of tele-communications without such controls become evident.

As a matter of fact, the word "cybernetics" actually means the science of politics: "the art of knowing not only what can be but also what must be done": statesmanship. The quoted definition is the translation of that provided in French by the electrical scientist Ampère in 1834 for the term "cybernétique" which he had introduced in his *Classification des Connaissances Humaines* (Classification of Human Knowledge). Ampère had derived the term etymologically from the Greek word, "Kybernetes", defined by Plato in his *Republic* as "the art of governing, the art of steering men."

It remains (1) to us very puzzling why, then, the electrical engineer, Norbert Wiener, would redefine the term in his *Cybernetics, or Control and Communication in the Animal and the Machine*, and also claim (his p. 12) that "the term does not date back further than the summer of 1947," thereby completely disregarding or ignoring the earlier uses of the term. The matter of Wiener becomes even more questionable when one finds that he repeats his claim in his 1950 book, *The Human Use of Human Beings*, a title of a clearly political oreintation! [One will find revealed Wiener's political orientation in the *Notices, American Mathematical Society*, Vol. 24, p. A-313 (1977) and Vol. 25: p. A-463 (1978).].

We have earlier (1,4) introduced the term, "tele-cybernetics" to mean either:

1. the science of politics in our Age of Tele-communications; or
2. tele-communications plus (proper) tele-control.

Despite Wiener's virtually non-academic behaviour in seeking the truth of this matter, we do agree that 'cybernetics' has two equivalent definitions:

1. "political science: the art of knowing not only what can be but also what must be done in human affairs"; and, therefore,
2. "control plus communication."

What, then, are the *proper* tele-controls which we must enact so as to ensure that reason prevails in our Age of Tele-communications? Written communications, subjected to proper social *controls*, constitute the foundation of the Enlightened Reason which accompanied the founding of our Republic. Indeed, it is *the political pursuit of the truth which guides the republic*. It follows that the propriety of any proposed tele-control mechanism rests on its capability to ensure that the truth prevails in matters political. The historical arrival of tele-communicative media does not change this requirement. Ampère's definition of "cybernétique" becomes interestingly quite the same as that of Wiener. Political science *is* communication plus its (proper) control.

5. THE 'DUSK' OF CIVILISATION: TELE-COMMUNICATIONS

The invention of radio and television has been the result of the application of the scientific knowledge, obtained in the nineteenth century, about the nature of electricity and magnetism (4). The obvious advantages of social tele-communications are its speed and the elimination of geographical and temporal barriers to the diffusion of messages. Conceptually, the analogous controls (such as the archival storage of written communications) could be exercised by the recording of tele-communications on tapes or video-disks/cassettes (for storage in secure repositories). Thus, the loss of messages and the willful or accidental distortion by erasures or splicing could be avoided, as was undertaken by the Vanderbilt University's Television News Archives.

Even though social tele-communications can be widely recorded (by means of video-cassette recorders), there had not been until quite recently a widespread effort by the professional librarian to catalog, store, and make available archivally these communications. The American Library Association's recently developed cataloguing formats for audio, video, and machine-readable tapes will allow for the acquisition and collection development by libraries of these relatively new forms of information storage. Currently, however, too often we professionals will not seek to verify or to confirm these tele-communicative messages by means other than our own 'mental recording' (our own recollections) of what has been said.

One might well reflect on the insight of Lewis Carroll (10), who noted that the mind seems to accept unquestionably as truth what is presented to it three times orally: "What I tell you three times is true". (*The Hunting of the Snark*).

One could note as well Payne's conclusion (11) that it was the advent of telecommunicative radio, rather than some alleged 'German psyche', which brought power to Hitler:

> "Hitler's rise to power coincided with the invention of the cheap, mass-produced radio that enabled him, though unseen, to become a living person in everyone's living room. He might have succeeded in dominating Germany without the advantages of absolute control over German radio stations, but without these advantages he would never have been so successful in establishing his totalitarian regime."

Any conscientious observer of America since World

War II would conclude that radio's progeny (TV) has led Americans, in the "liberal vs. conservative" debate, to a behaviour not too unlike that of the Germany of the 1930's. The British-American, Alistair Cooke, reported that, as a member of the White House 'Press Corps' in F. D. Roosevelt's first term, the radio was the source of FDR's power in convincing Ametica that it, like the then so successful Germany, wanted "national socialism." Especially is this so when one reflects on the revelation (12) of the politico-religious orientation of the leadership of our television industry, a point made by only a few. For example, C. West Churchman (13), apparently searching in the 1960's for the explanation for what he perceived to be a widespread 'challenge to reason', identified the "hidden leadership" of America: those who act on

> a desire to be leaders and controllers of public opinion.... And there is no guarantee that the hidden leadership itself is well informed."

The late Doctor John H. Knowles, then President of the Rockefeller Foundation, commented (14) on our "tele-cybernetics":

"As for Telecybernetics, I think you have some very good points about the Age of tele-communications.... Reality as it is conveyed by the mass media can... lead us one and all to believe things that simply don't exist." [28.VI.1978].

The Judicial Conference of the United States' recent dismissal of the argument that television is a means to public education is indeed an endorsement of such a view. In its report, television coverage of state court trials is presented as detrimental to the administration of justice: "there appears a great potential for miseducation and presentation of distorted images" from the broadcasting of "short segments of selected sensational cases." [New York Times, 21.IX.84; p. A19].

Tele-communications without (proper) "tele-controls" is an historically proven "Challenge to Reason". America's investment of many more lives in military activities in the Middle East (12) will not be avoided unless we undertake these tele-communicative controls.

On the positive side, the important tools of our Age of Tele-communications (computers, telephone, and television), when properly used, provide us the opportunity to understand better and to control both natural and social systems. For example, the relatively recent development of algorithmic simulation as the methodology for the scientist of systems (4,8) provides a path for Reason to travel. Computerised models make possible Man's voyages to, and his continuing exploration of, the Moon. Indeed, were it not for the "frenzied" simulations, computerised on Earth so as to determine the best course of action, astronauts of Apollo 13 might never have returned.

6. A FEW CONCRETE PROPOSALS FOR TELE-CONTROL

As we indicated above (Table I), there are three forms of inter-human communications: the person-to-person; the social; and the archival. Person-to-person tele-communicative media have historically been the telegraph and the telephone, though the development of the laser is making widespread the application of fibre optics as a person-to-person tele-communicative option, particularly so for digitised (including digitised voice) transmissions.

6.1 THE ELECTRONIC POSTMARK

By analogy with written person-to-person communications, what are the 'controls', even self-policing controls, which remain to be made 'standard operating prodedure' for person-to-person tele-communicative transmissions? We have already mentioned above the "electronic postmark", clearly an option which should be available to users of electronic mail. However, should not every telephone call transmit to the called, and make available to the called upon the lifting of his/her receiver, the electronic postmark: the telephone number and the Greenwich Mean Time of the origin of the call? Even from the cellular, transportable, telephones, which operate via radio, the telephonic message should be transmitted with this "electronic postmark." Terrorists could be considerably curtailed and clever computer hackers stymied by the electronic postmark, since immediate police access to the 'inverse directory' (yielding the location of any given number) would give either offender cause to pause. Note that we are not here proposing any 'invasion of privacy', for we are not proposing any third-party interception of the message. Since, in America, telephonic communications are operated by private businesses, then clearly their record-keeping (for the purpose of collecting service charges) has always been a 'third-party interception', if only for bhe electronic postmark's data. Particularly with the ever more ubiquitous nature of the digitised telephone, the capability to 'pick up' electronically and to transmit to the called this 'electronic postmark' is becoming wieldy.

6.2 THE ELECTRONIC CARBON COPY

The carbon copy (and, more recently, the photocopy) has been, for the written word, the ideal method by which we keep an exact record of what message we had transmitted to a business or professional counterpart. Where, in our Age of Tele-communications, is the "electronic carbon copy"?

We suggest that it become standard operating procedure that business and professional telephonic calls be recorded (with their accompanying electronic postmark) at each end. Again, we are not proposing any 'invasion of privacy': everyone would know (or, would expect) that his business or professional telephonic communications are likely being recorded by the other party on the line. In our many conversations at professional meetings at which we have made this suggestion, we have received reactions, often negative at first, though almost always in agreement once it is made clear that the practice of recording business and professional tele-communications at both ends is to have become "standard operating procedure" and that legislated controls on the common carriers (the telephonic enterprises) are established so as to avoid third-party interception (except when there be established reasonable suspicion of the transmission from some receiver of either pornographic of treasonous material).

6.3 ENCRYPTION: THE ELECTRONICALLY SEALED LETTER

Similarly, where is the concept of the 'sealed letter' in telephonic communications? Postal services were established so that letters between citizens could be assumed to have been kept confidential during their transmittal. This is the reson that the US Constitution gives Congress the right to operate post offices and post roads. The notion of the "electronic sealed letter" is best accomplished by encryption. The encrypted message, if intercepted along its path of transmission, still needs to have its "seal" (its code) broken.

6.4 THE ELECTRONIC CERTIFICATE OF MAILING

To pursue further the topic, what about an "electronic certificate of mailing," a documentary proof that a telephonic message had been sent (i.e., that an item had been submitted to, entered into, the electronic mail system? Could a citizen fault the postal or telephonic authorities if, when writing to the FBI in order to report the existence of spying [Newsweek, 3.IX.1979; p. 23] by fellow citizens/denizens, he/she finds that either his/her message or their reply is either undelivered or intercepted? The 'electronic certified letter' could be accomplished by having the electronic mail system or the telephonic system provide with its electronic postmark a message to the sender that indeed the communication had been established or completed. Indeed, for a fee, receipts could be provided for the paragraph-by-paragraph communications during transmission (i.e., in 'real time').

Charges for long-distance telephonic calls currently provide this information/certification, though only periodically to the originator of the communication (with the arrival of the monthly statement of service charges). What we are proposing is that a mechanism be established by which an immediate certificate of dispatch could be provided to the sender.

6.5 THE ELECTRONIC RECEIPT OF TRANSMISSION

Similarly, one could obtain the return receipt (of the place and the Greenwich Mean Time of delivery) by having the electronic mail system (and the telephone system) emit to the receipient a very short (scrambled or encrypted) note, then not allow the receipient to begin receiving the message until he/she returns electronically the scrambled message (letter-perfect). A similar return of periodically-spaced (say, paragraph-by-paragraph) encryptions would thereby ensure that the called/addressee was indeed receiving the message via the electronic mails.

6.6. THE ELECTRONIC SIGNATURE

If one seeks an "electronic signature" for a "signed" receipt of certified mail delivery, perhaps we shall need await the development of the machines which read "smart cards" to require and to read signatures, then confirm via computerised pattern recognition techniques that the signature is valid.

7. TELE-CONTROLS:
THE SOCIAL TELE-COMMUNICATIVE MEDIA

As for the social tele-communicative media (radio and TV), we have indicated above a number of policies which need to be implemented. We would do well to note that television is the 'child' of two technological parents: radio and cinema. Those of us who feel that cinema was as large a factor in America's loss of the Vietnam War as was television (e.g., General Westmoreland's current lawsuit against CBS) should note how much more widespread, how much more pervasive, is television. The mass of our American citizenry is subjected to a sequence of 'shows' and 'serials' which center on the vein, the ludicrous, the immoral. Even more to the point, in how many 'sitcoms' is the leading actor (such as in 'father knows well') correcting, by way of asking, his wayward offspring whether his/her planned or proposed action is in the best interest of his/her country?

7.1 BROADCASTING AND CANCER: CAUSE-AND-EFFECT?

Television and FM radio broadcasting present another peril, much suppressed for some reason by the moguls of our broadcasting industry. As the senior author had pointed out earlier (16,17,18), there is a likely cause-and-effect relationship between FM (therefore TV) broadcasting and cancer. Now, both the journals of technology (19) and of science (20) confirm that this is likely so. There do exist cytogenetic (cancer-producing) hazards of FM/TV broadcasting.

7.2 THE MORALITY QUESTION

The more dangerous threat, however, of uncontrolled social tele-communicative media (radio and television) is the 'moral cancer' which they have introduced in America. Any cytogenetic hazard of regular FM/TV broadcasting can probably be alleviated by a wholesale shift from broadcast to cable television (and radio), probably even better accomplished via fibre optical cables.

Among the leaders of the advocates of morality in television broadcasting has been the Reverend Donald Wildmon, whose National Federation for Decency places its focus on appealing to advertisers not to support television shows deemed immoral, indecent. We certainly commend their efforts, but wish that they would place more emphasis on locating producers which stress patriotism. The patriotic American cannot tolerate the immoral broadcast, for he knows how this weakens his fellow citizen's resolve. After all, the tele-communicative media serve as every citizen's, particularly the child's, sensor of the world about him. If his 'electronic sensor' is failing him, he will only act accordingly (i.e., wrongly; not in consonance with the actual truth). Since the process by which truth is ascertained is a six-stage model-building process (1,4) which mimes Nature's earlier model-building processes (first genetic, then neural) for ensuring survival, the need for proper controls, even tele-controls, of the social tele-communicative media are of paramount importance.

7.3 ENHANCING BROADCASTING AS A DEBATING FORUM

Just as important is the need to establish television as a forum for rational debate. Our Nation's loss of the war in Vietnam is clearly the result of television broadcasting. We are now so imbedded in our Age of Tele-communications that many still believe our lack of resolve to be due to the 'power of the press', to our leading newspapers, particularly those in New York City and Washington, DC. Yet, newspapers today have opted, as a defense mechanism for their own survival, to mime many of the antics of the television broadcasting medium. They proceed with haste, with a desire to perpetuate the image that they themselves remain the leaders and the controllers of public opinion. Both the newsprint and broadcast media rely on the tele-communicative news services (21), themselves devoted to haste rather than thoroughness or truth.

What kind of 'controls' can be applied to correct the excesses of television news broadcasting? We might do better to 'democratise' news reporting more, to allow a local reporter's videotape to serve as the report of a television network, rather than have virtually every event of national interest covered and reported by a member of the national network's staff.

7.4 THE VIDEO-TEXT NEWS RELEASE

Even more importantly, we feel, would be for each government agency to prepare daily a video-text 'news release,' much as the FBI does now, for distribution to any interested parties, including therefore network and local news media. We would even suggest that these video tapes/cassettes (as opposed to mimeographed news releases) be considered by their respectively issuing agencies as "the (final) word of the day," though we do not intend to suggest that any errors remain uncorrected or that any ambiguities remain unchallenged or unclarified.

What we do intend to suggest, however, is that we feel that our country has allowed the tele-communicative media to become the "tail which is wagging the dog," our nation. Clearly, the proper roles need to be reestablished before we find our country pushed into some irrational conflict. The concept of a video-taped 'news release', daily even from the White House, could help to restore the proper order.

7.5 ELECTRONIC 'LETTERS TO THE EDITOR'

As for television documentaries, is it not true that the typical among them leave the particular issue at hand unresolved, leave the viewer/listener with the impression that the issue is still 'controversial' or that it requires further study? C. West Churchman (13) has made this point very well:

> "in our society there is a 'hidden leadership' which operates by attracting attention of the society to certain issues and consequently neglecting other issues. Thus at one time we are concerned about the possibility of fallout, but a few years later we forget and are excited about juvenile deliquency, then about civil rights. In all these cases each problem continues to exist—possibly in an even more severe fashion—than it did when the public was paying attention to it....Consequently, the well-informed citizen is well-informed about the issues that the hidden leadership causes him to be well-informed about, and he neglects the issues that the hidden leadership causes him to neglect."

What we need to impose on the 'host' in any documentary presentation on TV is not so much that he/she give us a lengthy list of publications to locate in our libraries but, rather, that he/she give us his/her own conclusion regarding the 'controversy' of the documentary. There seems to be no way more sure to correct an erring author than to have his opinion or conclusion clearly stated; this is partly the reason why the 'Letters to the Editor' columns in periodicals are frequently more dense with facts than the periodical itself. Should we not expect that "TV journalists", "TV documentarians", give us as the conclusion of their show/interview, their personal (hopefully informed) opinion of the conclusion(s) which they have reached as a result of their investigations/interviews?

7.6 THE ELECTRONIC POSTMARK REVISITED

We would even suggest that each video-text, particularly any incorporated in a news broadcast, should have with it its own accompanying 'electronic postmark': the Greenwich Mean Time and the location at which the video-camera was in operation. This 'electronic postmark' would serve as would the date on a piece of correspondence duplicated and published in a bound book. Any home receiver could be equipped to suppress the display of the electronic postmark should the viewer find it annoying, though video cassette recorders should be equipped to 'capture' the electronic postmark, perhaps without option.

7.7 THE ELECTRONIC COPYRIGHT

The notion of the 'electronic carbon copy,' so pertinent we feel to person-to-person communications, has merit with respect to its application in social tele-communicative media as well. The Vanderbilt University Television News Archives is a case in point, and the now quite widespread ownership of video-cassette recorders can only aid in this aspect of tele-control. However, how is to be determined the 'copy of record,' the authoritative copy of what had been broadcast? Does not a copyright procedure need to be invoked, with (say) the Library of Congress maintaining (as they do for published/printed material) the 'copy of record'?

8. ARCHIVALLY-PRESERVED TELE-COMMUNICATIONS

We now turn to the third form (cf. Table I) of tele-communications and their proper tele-controls. Not only should news broadcasts be copyrighted and archivally preserved, but also so should be computer programmes (5, e.g.). The manufacturers of computer games and computer software (such as word processing or spreadsheet routines) are quickly realizing the commercial need for the copyright of computer programmes (22).

We have maintained (8,23) that every computer programme is actually an algorithmic *simulation* model, providing a simulation of something, of some process, of some (typically human) activity. Since we seek to have scientifically credible models of living systems, best accomplished by means of the algorithmic (as opposed to the mathematical) model, then the scientific community indeed requires a copyright procedure for their machine-readable programmes (22). The 'copy of record' need also be maintained in an archival repository, in the machine-readable form (8,22).

Establishing these methods of 'tele-control' means that a rational debate can be conducted, even in our Age of Tele-communications. The truth, both scientific and political, can be made to prevail.

As a corollary to our proposal (8,22) that there be an archival repository and a copyright procedure for both broadcast and programmed tele-communications, one should note the importance of Presidential candidate Mondale's concern about leaving war-making decisions "to a computer." Without realising it, he was raising the very issue which many of us have been attempting (9,23) to highlight in simulation methodology: viz., model credibility. It is not the computer (the hardware) which will likely be making these military decisions of national survival; rather, it is the computer programme (the software), the simulation model, the artificially intelligent programme which will be making the decision. Are we making certain that our simulation models are scientifically credible? Doesn't national survival require that we do so?

As another corollary to this proposal, one should note that the scientist's desire to establish priority of publication would be considerably enhanced by means of a standardised, nationally controlled, electronic postmark.

We will close with one other observation, one dealing with a subject which has even arisen from distraught publishers who have seen their sales of printed volumes decrease as a result of copying machines. A similar stress is awaiting the 'manufacturers' of video-cassettes and computer software, since these can be readily duplicated by most purchasers owning or having access to a personal computer. Have we not failed to engage the minds of America's brilliant engineers and technologists by asking them how these 'duplicating machines' can be constructed so as *not* to duplicate copyrighted material? Cannot the inks in materials for which duplication *is* permitted be 'chemically coded' so that a duplicating machine would copy *only* from material giving this signal? Could not the 'tracks' on tapes, cassettes, and video-disks include a 'channel,' perhaps part of the electronic postmark itself, or a code which would either permit or preclude any duplication?

9. CONCLUSIONS

Our challenge and responsibility today is the reduction of erroneous (negative) decisions and the reinforcement of correct (positive) actions. It is, as West Churchman writes, our "challenge to reason" in our Age of Tele-communications, communications still inadequately controlled.

The history of the evolution of any field of human endeavour is the account of the success or failure of its models (whether physical or literal) to explain and to predict natural phenomena. Whether one considers the philosophical problems of humanists, or the scientific and mathematical puzzles of the classical scientists, or the behavioural enigmas puzzling social and political scientists, the ultimate concern remains the same: the meticulous adherence to a disciplining which ensures both the correct diffusion of insights and the reduction of their errors. These are the 'controls' needed in human communications.

Museums and libraries have proved the essence of the control on Man's physical and literal models. In our Age of Tele-communications, an archival repository of algorithmic computer models *and* tele-communicative broadcasts is in order. More importantly, one must ensure that the collective mental models, formed in neural recordings of individuals by the social tele-communicative media, are subjected to proper "tele-control." We need the electronic postmark, the legality of the electronic carbon copy. We require 'tele-cybernetics':

> "For here (America) we are not afraid to follow truth wherever it may lead,
> Nor to tolerate error so long as reason is left free to correct it."
>
> —Thomas Jefferson

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An Analysis of High and Low Priority Data Traffic Using Busy Periods and Slack Periods

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1. Abstract

In an integrated voice and data communications network, data traffic may be differentiated into high and low priority classes. During periods when transmission resources designated for high priority data packets are not otherwise in full use, low priority data packets might be transmitted. We derive expressions for the length of time that the designated transmission resources are alternately in full use and not in full use by high priority data packets, the increase in low priority data packets during periods when the designated resources are in full use and the spare transmission capacity available when the designated resources are not in full use.

2. INTRODUCTION

2.1 BACKGROUND

Separate networks for voice communications and data communications have existed for some time. Because of advances in digital transmission techniques, there have been proposals [2], [3], [5] that both voice and data traffic be carried over the same digital telecommunication network, which will be referred to as an integrated network. It is believed that this would lead to a better use of the transmission resources. In view of advances in areas such as computer voice understanding and voice output, a common backbone network would anticipate the needs for interactions between voice network and data network users, and would offer a wider range of services to subscribers of an integrated network.

To allow for the circuit-switching of voice calls and the packet-switching of data packets in an integrated network, the transmission link between two nodes may be shared by a time-division multiplexing scheme based on the Slotted Envelope Network concept [2], where part of the time voice calls (which have been digitized) are transmitted and part of the time data are transmitted. Units (packets) of digitized voice and data are transmitted at regular intervals called frames. A frame is further partitioned into intervals called time slots, which are allocated to voice and data packet traffic, each awaiting its turn for transmission during a frame. Variations on this basic frame structure are described in [4]. The number of time slots allocated to each type of transmission may be fixed or variable, and a frame is said to have a fixed or movable boundary between the two types of transmission [5] respectively.

2.2 TRAFFIC CLASSES

Coviello and Vena [2] identified three major classes of traffic in an integrated switching network, namely, voice calls, data packets requiring prompt delivery (high priority data packets), and other data packets (low priority data packets). Voice calls are characterized by long holding times (of the order of 100 sec) relative to the duration of a frame (of the order of .01 sec). Data packets, in contrast, complete transmission in one frame and may be delayed to some extent. In the case of high priority data packets, only small delays are tolerable. Low priority data traffic does not have stringent delivery time requirements.

2.3 USE OF IDLE SLOTS

To maintain high quality service, slots designated for voice and high priority data traffic will necessarily be idle from time to time. Potential uses for the slack transmission capacity, on a low priority basis, may be the transfer of files between remote computers, and the transport of electronic mail. The mail may be in the form of text messages, recorded voice messages, facsimiles or video images.

Because of the large difference in the holding time of voice calls and data packets, one may offer two grades of low priority service by separating low priority data packets into two streams: class V and class D. Class V data packets are allowed to use residual voice slots for transmission while class D data packets are allowed to use residual high priority data slots. Since voice calls have a relatively long holding time, voice slots may not be available for the transmission of class V data packets for an extended period of time. As a result, class V data packets may experience a longer and more variable waiting time than their class D counterpart.

In this paper, we present an approximate analysis of high priority and the associated (class D) low priority data traffic; other possible transmission schemes and an approximate analysis of voice and the associated (class V) low priority data traffic are described in [6], [7].

2.4 WAITING ROOM CAPACITY

Since high priority data packets must not be delayed for long, it is appropriate to limit the number of these data packets that may wait for transmission. Rather than permitting their queue to grow without bound, one should allocate sufficient slots to high priority data packets to insure a short waiting time and a low probability of data packets being blocked.

For low priority data packets, time delays are not crucial and a queue of low priority data packets awaiting transmission would keep the otherwise idle high priority data slots occupied. During the time when high priority data packets are occupying all of the designated slots, it is necessary to provide a large waiting room to store the low priority data packets. We assume for our analysis that the waiting room for low priority data packets is infinite.

2.5 OVERVIEW

We note that designated slots for high priority data packets are alternately in full use and not in full use. We call the duration of time that all the designated slots are in use by high priority data packets a busy period and the duration of time that some residual slots are available a slack period. We shall find the mean and variance of the length of busy periods and slack periods, the increase in the low priority queue during busy periods of high priority data traffic and the spare transmission capacity available in slack periods.

The probability distribution for the number of occupied high priority data slots in the first transmission frame of a slack period is different from what it is in the other frames of a slack period; we shall show how the probability distribution may be computed.

3. BUSY PERIODS OF HIGH PRIORITY TRAFFIC

We shall describe a general model which may be used to find the length of time that all the allocated slots are occupied by high priority data packets.

The general model consists of a server that can serve up to c customers at one time. The server is available to waiting customers at variable intervals called service periods; customers being served complete their service requirements in one service period. At the beginning of a service period, the server starts to serve as many customers as are waiting, up to a maximum of c. Customers who arrive in the middle of a service period have to wait for the next available service period. The server will start a new service period immediately after one service period expires -- even if there are no customers in the system. The number of arrivals in a service period is independent and identically distributed. Up to N waiting customers, $c<N<\infty$, can be accommodated.

For our model, we define a busy period as the time interval from the instant just before the start of a service period when there are c or more waiting customers to the first instant just before the start of a service period when there are less than c waiting customers. A j-busy period, $c \le j \le N$, is a busy period with the initial condition that there are j waiting customers just before the start of a service period (cf. [1]).

Let Y denote the duration of a busy period and $B(s)$ be the Laplace-Stieltjes transform of its probability density function. Let Y_j, $c \le j \le N$, denote the duration of a j-busy period and $B_j(s)$ be the Laplace-Stieltjes transform of its probability density function. Let X denote the duration of a service period and $G(s)$ be the Laplace-Stieltjes transform of its probability density function. Let $P(z)=\sum_{i=0}^{\infty} p_i z^i$ be the probability generating function of the number of arrivals in a service period and $P_i=\sum_{j=i}^{\infty} p_j$ the probability of i or more arrivals.

Conditional on the event that there were no waiting customers just after the start of the preceding service period and that there were c or more arrivals during service, a busy period begins with j customers in the system, $c \le j < N$, with probability p_j/P_c and with N customers in the system with probability P_N/P_c. Hence $B(s)$ and $B_j(s)$, $c \le j \le N$, are related by the following equation:

$$B(s)=\sum_{j=c}^{N-1} p_j B_j(s)+P_N B_N(s)/P_c \tag{1}$$

$B_j(s)$, $c \le j \le N$, satisfy the following system of functional equations:

For $c \le j \le min(2c-1,N)$

$$B_j(s)=\sum_{i=0}^{c-(j-c)-1} p_i G(s)+\sum_{i=c-(j-c)}^{N-(j-c)-1} p_i B_{i+j-c}(s)G(s) + P_{N-(j-c)}B_N(s)G(s) \tag{2a}$$

If $N \ge 2c$, then for $2c \le j \le N$

$$B_j(s)=\sum_{i=0}^{N-(j-c)-1} p_i B_{i+j-c}(s)G(s)+P_{N-(j-c)}B_N(s)G(s) \tag{2b}$$

The system of functional equations is, in general, difficult to solve. Noting that $\overline{Y_j^n}=(-1)^n B_j^{(n)}(0)$ where $\overline{Y_j^n}=E(Y_j^n)$ and $B_j^{(n)}(s)=d^n/ds^n B_j(s)$, one may compute the mean and higher moments of Y_j, $c \le j \le N$, by repeatedly differentiating equation (2) and substituting $s=0$, and solving the resulting system of linear equations. To illustrate, we write down the system of linear equations for $\overline{Y_j}$.

For $c \le j \le min(2c-1,N)$

$$\overline{Y_j}=\bar{X}+\sum_{i=c-(j-c)}^{N-(j-c)-1} p_i \overline{Y_{i+j-c}}+P_{N-(j-c)}\overline{Y_N} \tag{3a}$$

If $N \ge 2c$, then for $2c \le j \le N$

$$\overline{Y_j}=\bar{X}+\sum_{i=0}^{N-(j-c)-1} p_i \overline{Y_{i+j-c}}+P_{N-(j-c)}\overline{Y_N} \tag{3b}$$

It may be shown that $\overline{Y_j^n}$, $n>0$, $c \le j \le N$, satisfy a linear system of the form Ax=b where A remains the same for all $n>0$ and where b is expressed in terms of previously computed values $\overline{Y_j^m}$, $0<m<n$, $c \le j \le N$. Thus one may compute higher moments of Y_j, $c \le j \le N$, successively.

Since a busy period is composed of j-busy periods, $c \le j \le N$, one can express the moments of a busy period in terms of the moments of j-busy periods. From equation (1), $\overline{Y^n}$ and $\overline{Y_j^n}$, $n>0$, $c \le j \le N$, are related thus

$$\overline{Y^n}=\sum_{j=c}^{N-1} p_j \overline{Y_j^n}+P_N \overline{Y_N^n}/P_c \tag{4}$$

Returning to our transmission scheme, we see that a transmission frame corresponds to a service period of constant duration in the general model. Using one transmission frame period as the time unit, we obtain $E(X^n)=\overline{X^n}=1$, $n>0$, and we may compute the mean and variance of busy periods for high priority data packets by the procedure outlined in this section.

4. A PARADIGM FOR FINDING THE INCREASE IN LOW PRIORITY QUEUE LENGTH AND THE EXCESS TRANSMISSION CAPACITY

We define a random variable H as follows.

$$H=\sum_{i=1}^{L} D_i-\sum_{i=1}^{L} F_i$$

where L is an integer valued random variable with mean $E(L)$ and variance $Var(L)$, random variables D_i, $i>0$, are independent and identically distributed with mean $E(D)$ and variance $Var(D)$, random variables F_i, $i>0$, are independent and identically distributed with mean $E(F)$ and variance $Var(F)$, and $\sum_{i=1}^{L} D_i$ and $\sum_{i=1}^{L} F_i$ are independent of each other.

H may be used to represent the increase in the low priority queue during busy periods of high priority traffic or the excess transmission capacity in slack periods where L represents a period of time measured in number of service periods or frame periods. D_i and F_i may stand for the number of customer or low priority data packet arrivals and departures in a service period respectively when H is used to represent the increase in low priority queue length; or the number of available slots and low priority data packet arrivals in a service period respectively when H is used to represent the excess transmission capacity. The mean and variance of H are obtained as follows.

$$E(H)=E(L)(E(D)-E(F)) \quad (5)$$

$$Var(H)=E(L)(Var(D)+Var(F))+(E(D)-E(F))^2 Var(L) \quad (6)$$

5. INCREASE IN LOW PRIORITY QUEUE DURING BUSY PERIODS OF HIGH PRIORITY TRAFFIC

Assume that the number of low priority data packets that arrive in a frame period is independent and identically distributed with mean $E(Q)$ and variance $Var(Q)$. Let m be the number of transmission slots allocated to low priority data packets. If the number of low priority slots, m, is not greater than the mean number of low priority arrivals, $E(Q)$, the low priority queue is rarely empty during busy periods of high priority traffic when no residual high priority slots are available. Assuming that the low priority queue is non-empty throughout a busy period of high priority data traffic, the number of transmitted low priority data packets per frame in a busy period has mean m and variance 0; and one may make the approximate assumption that the number of low priority arrivals and low priority departures in a busy period are independent.

Having computed the mean and variance, $E(Y)$ and $Var(Y)$, of a busy period of high priority traffic, one may substitute $E(Y)$ and $Var(Y)$ for $E(L)$ and $Var(L)$, $E(Q)$ and $Var(Q)$ for $E(D)$ and $Var(D)$, and m and 0 for $E(F)$ and $Var(F)$ in equations (5) and (6) and approximately find the mean and variance of the increase in the low priority queue during a busy period of high priority traffic.

6. EXCESS TRANSMISSION CAPACITY IN SLACK PERIODS

A busy period is followed by a slack period which is the time interval from the instant just before the start of a service period when there are less than c waiting customers (or high priority data packets) to the first instant just before the start of a service period when there are c or more waiting customers, c being the maximum number of customers (or high priority data packets) that may be served in a service period. During a slack period of high priority data traffic, some of the designated slots are not in use by high priority data packets. We shall find the excess transmission capacity available in a slack period.

Let S denote the duration of a slack period. Since a slack period is terminated when there were c or more arrivals in the preceding service period or transmission frame, the probability that a slack period has a duration of j, $j>0$, service periods is given by $(1-P_c)^{j-1}P_c$, P_c being the probability of c or more arrivals. The mean and variance of the length of a slack period are given by

$$E(S)=1/P_c$$

$$Var(S)=1-P_c/P_c^2$$

Except for the first frame of a slack period, the number of occupied high priority slots in a frame is given by the number of high priority data packets that arrived in the preceding frame. The probability of i high priority data packet arrivals, $0 \le i < c$, in a frame during a slack period is $p_i/1-P_c$. Knowing the probability distribution of the number of slots occupied by high priority data packets, one may find the probability distribution of the number of residual slots in a frame. From the probability distribution of the number of residual slots, one may obtain the probability distribution of the maximum number of low priority data packets, denoted by M, that may be transmitted in a frame during a slack period and compute the mean and variance of M.

The difference between the sum total of the maximum number of low priority data packets that may be transmitted in each frame and the total number of low priority data packet arrivals during a slack period is the excess transmission capacity that may be used to relieve the low priority queue. The probability distribution of the number of slots occupied by high priority data packets in the first frame of a slack period is different from those of the rest of a slack period. We shall show how the probability distribution may be calculated. As a conservative estimate, one may assume that no residual slots are available in the first frame, and substitute $E(S)-1$ and $Var(S)$ for $E(L)$ and $Var(L)$, $E(M)$ and $Var(M)$ for $E(D)$ and $Var(D)$, and $E(Q)$ and $Var(Q)$ for $E(F)$ and $Var(F)$ in equations (5) and (6) to compute the mean and variance of the excess transmission capacity available in a slack period.

7. OCCUPIED SLOTS IN THE FIRST FRAME OF A SLACK PERIOD

The probability distribution of the number of slots occupied by high priority data packets in the first frame of a slack period may be computed by the following procedure.

Let v_i, $0 \le i \le N$, be the probability that there are i high priority data packets just before the start of a frame; the calculation of the probability distribution will be shown shortly. From the second frame to the last frame of a slack period, the probability of i high priority data packets, $0 \le i < c$, present just before the start of a frame is equal to the probability of i arrivals in the preceding frame conditional on less than c arrivals, which is given by $p_i/1-P_c$.

During a slack period (including the first frame), the number of slots occupied by high priority data packets ranges from 0 to $c-1$; and it is only during slack periods that the number lies in that range. Weighting the probability of i occupied slots, $0 \le i < c$, from the second frame to the last frame of a slack period by $E(S)-1/E(S)+E(Y)$, S and Y denoting the length of a slack period and a busy period respectively, we calculate Δ_i, $0 \le i < c$, as follows.

$$\Delta_i = v_i - p_i/1-P_c E(S)-1/E(S)+E(Y)$$

Let

$$r_i = \Delta_i / \sum_{i=0}^{c-1} \Delta_i$$

Then the probability of i occupied slots, $0 \le i < c$, in the first frame of a slack period is given by r_i.

8. PROBABILITY DISTRIBUTION OF HIGH PRIORITY DATA PACKETS

The probability distribution of the number of high priority data packets present just before the start of a frame is given by the invariant probability vector of the state transition probability matrix, which we now describe. Let $V=(v_{ij})$, $0 \le i, j \le N$, be the state transition probability matrix of the number of high priority data packets present just before the start of a frame; v_{ij} is the probability that there will be j high priority data packets present at the start of the next frame, given that there are i high priority data packets present at the start of the current frame.

V may be factored into the form

$$V=W\,U$$

where W is the transition probability matrix of the number of data packets waiting for transmission just after the start of a frame given the number of waiting data packets just before the start of a frame, and U is the transition probability matrix of the number of data packets at the end of a frame given the number present just after the start of the frame.

Let $W=(w_{ij})$, $0 \le i \le N$ and $0 \le j \le N-c$. For $0 \le i \le c$,

$w_{i0}=1$

For $i=c+j$, $1 \le j \le N-c$,

$w_{ij}=1$

All other entries of W are zero.

Let $U=(u_{ij})$, $0 \le i \le N-c$ and $0 \le j \le N$. For $0 \le i \le N-c$ and $i \le j < N$,

$u_{ij}=p_{j-i}$

where p_i is the probability of i high priority data packet arrivals. For $0 \le i \le N-c$ and $j=N$,

$u_{ij}=P_{j-i}$

where P_i is the probability of i or more arrivals. All other entries of U are zero.

The invariant probability vector of V may be found by first calculating the invariant probability vector of a smaller matrix $\hat{V}=U\,W$. Let θ be the invariant probability vector of $\hat{V}$. Then the invariant probability vector of V is given by

$v=\theta U$

9. PROBABILITY OF LOSS OF HIGH PRIORITY DATA PACKETS

Loss of high priority data packets occurs when there are i, $0 \le i \le N-c$, waiting high priority data packets present just after the start of a frame and there are more than $N-i$ arrivals during the frame. The probability distribution of the number of high priority data packets present just after the start of a frame is given by

$w=vW$

Let $w=(w_i)$, $0 \le i \le N-c$. Then the probability of loss is given by

$$\sum_{i=0}^{N-c} w_i P_{N-i+1}$$

10. NUMERICAL EXAMPLES

In the numerical examples, the size of the waiting room is four times the number of transmission slots. Data packets arrive according to a Poisson process. We calculate the probability of loss of data packets for Tables 1 to 3 where the utilization of the transmission slots ranges from 0.85 to 0.95 and the number of slots ranges from 8 to 32. As we increase the number of slots and proportionally the size of the waiting room, it is possible to attain a high utilization of the transmission slots while maintaining an acceptable probability of loss. Depending on the number of slots and the size of the waiting room, one may operate the transmission slots in the range of 0.8 to 0.9 utilization without entailing a high probability of loss. Because of the already high utilization of the transmission slots, one may choose not to share the use of slots with low priority data packets to reduce the overhead involved in managing the slots.

We also calculate for the traffic parameters of Tables 1 to 3 the mean queue length of high priority data packets. From the displayed figures, we see that the mean queue length does not exceed twice the number of transmission slots, and this means that on average the waiting time for transmission is two frame periods or less.

Tables of probability of loss of data packets

trans. slots	waiting room	arrival rate (per frame)	utiliz.	probability of loss	mean queue length
8	32	6.8	.85	1.0×10^{-4}	8.5
16	64	13.6	.85	5.5×10^{-8}	14.9
32	128	27.2	.85	1.6×10^{-13}	28.1

Table 1

trans. slots	waiting room	arrival rate (per frame)	utiliz.	probability of loss	mean queue length
8	32	7.2	.90	1.2×10^{-3}	10.3
16	64	14.4	.90	1.1×10^{-5}	17.2
32	128	28.8	.90	5.6×10^{-10}	31.0

Table 2

trans. slots	waiting room	arrival rate (per frame)	utiliz.	probability of loss	mean queue length
8	32	7.6	.95	1.1×10^{-2}	13.9
16	64	15.2	.95	1.2×10^{-3}	22.5
32	128	30.4	.95	1.2×10^{-5}	37.2

Table 3

With the same traffic parameters of Tables 1 to 3, we compute the mean and coefficient of variation of the length of busy periods and slack periods, which are displayed in Tables 4 to 6. From the tables, we see that the mean length of a busy period does not exceed 10 frame periods. The relatively short busy period may be accounted for by the fact that data packets complete transmission in exactly one frame period and arrivals in excess of the size of the waiting room are blocked.

Tables of length of busy and slack periods

trans. slots	wait. room	arvl rate (per frame)	busy period		slack period	
			mean	cf var	mean	cf var
8	32	6.8	3.3	1.2	2.7	.80
16	64	13.6	2.3	.98	3.4	.84
32	128	27.2	1.7	.76	5.0	.89

Table 4

trans. slots	wait. room	arvl rate (per frame)	busy period		slack period	
			mean	cf var	mean	cf var
8	32	7.2	4.9	1.5	2.3	.75
16	64	14.4	3.5	1.3	2.7	.79
32	128	28.8	2.5	1.0	3.3	.84

Table 5

trans. slots	wait. room	arvl rate (per frame)	busy period		slack period	
			mean	cf var.	mean	cf var
8	32	7.6	9.4	1.8	2.0	.71
16	64	15.2	7.0	1.8	2.2	.75
32	128	30.4	5.0	1.5	2.4	.76

Table 6

11. ACKNOWLEDGEMENT

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Technology Innovations for Special Applications

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1. Abstract

Telecommunication technology that has been designed mainly to meet the requirements of the industrialised countries does not fully meet the needs of the developing countries. The technology is also required to promote large scale education and economic development programs. This paper looks at the possible technology innovations to meet this goal.

2. INTRODUCTION

During the past decade, communication technology has made rapid strides that have resulted in a wide variety of new services. These are far beyond the plain ordinary telephone service - POTS and telex. However, in many less industrialised countries, even basic elements of POTS do not exist. While these countries are trying to cope up with the problem of providing basic services, pressures are building up for introduction of modern telecommunication technology. There is a difference between the actual needs and the needs as perceived from outside. As a result there is a mismatch between the requirements and the advanced communication technology that has been developed mainly for the industrial countries, can provide. Apart from the well known problems of high traffic and low density, there are other important issues that require urgent attention. More important of these relate the type of services, environmental and operational constraints and transfer of know-how (if any). There are also special needs for aiding education and development. We shall discuss some of these and examine possible solutions. It may be noted that it is not necessary to devise an entirely new set of systems and techniques; developments in other areas of communication can be adapted and integrated for this purpose.

3. PROBLEM AREAS AND SPECIAL NEEDS

In developing countries, communication needs are strongly influenced by such factors as lack of resources, traffic pattern, multiplicity of languages, poor physical environment, inadequate manpower with required skills and cultural factors that impede absorption of high technology. Some problem areas are as follows:

Problems related to services and applications. The critical need is still for simple plain old telephone service that is always available and reliable. Data networking and facilities for the office of the future are less important. The traffic per line is much higher while the density-number of lines per unit area is low. This situation is just the opposite of what prevails in the developed world. It is more important to have access to a telephone than owning one, which means the network has to support a relatively larger proportion of public and coin telephones. Reliable, low cost, ~~tamper~~ free coin telephone for local as well as long distance application is urgently needed. So far as the data services are concerned, a low cost telegraph (telex) service will meet majority of the requirements. But multiple languages and scripts in some countries cause serious problems. Low cost facsimile may provide an answer.

Operation and maintenance is another area of great concern. In rural areas it is difficult to provide closely controlled airconditioned environment to the equipment. The equipment must be capable of operation in a non-airconditioned dusty environment atleast for short spells of periods if not all the time. Further, due to paucity of skilled staff, the maintenance operation has to be highly simplified and the man-machine interface should made more use of audio/visual/graphics facilities to make it less dependent on local languages and specialized skills.

Since the primary goal is to provide some minimum basic communication facilities, rather than the most sophisticated, one can consider a few special adaptations at the tail ends of the network (which lie in rural areas) without affecting the core of the network. Judious use of radio frequency channels would help in reducing the line cost. Recent developments in low cost signal processing microcomputers would be very useful for this purpose.

Local assembly and manufacture is a problems not just of economics of scale. Technology transfer is hampered by factors such as shortage of skilled manpower and cultural barriers. However, in recent years, with the availability of low cost digital - LSI components system are built from far fewer types of subsystem/card types than before. This has made the manufacturing operation look more like an assembly operation, which simplifies the transfer of technology.

Communication technology has an important role to play in education and training. In the industrialized world the multichannel TV network with wide coverage and supported by the narrow band telephone network provides a strong base. No such facilities are normally available in developing country. A number of solutions, including those based on satellite links have been planned and experimented, but their overall impact has been somewhat limited. It might be worthwhile to examine other alternatives like using the radio channels for broadcasting audio visual information for mass education. One can exploit the low cost of VLSI hardware for this purpose.

Appropriate technology for developing countries has has been a subject of discussion for some time. One of the ideas that have been propagated is that the "older" technology is better suited for the developing countries. Unfortunately this is not the situation. If anything, the need is for more sophisticated techniques. Reliable, low cost structurally simple systems capable of operation under highly adverse environmental conditions with poor quality channels are required. It is not necessary to develop systems denovo; one can well benefit from others experience. Systems developed for defence applications can be adapted here. Similarly one can desire much benefit from the experience of radio amateurs who now transmit data and pictures on h.f. channels. This approach may appear to be expensive, but lack of adequate communication turns out to be even more expensive!

4. SYSTEMS AND IDEAS

We present here a few innovations that are of relevance to the developing countries.

4.1 LOW COST TELEGRAM SERVICE

There have been several interesting satellite based systems/proposals of relevance to the developing countries systems. Some work has been done for a DAMA for rural application[1]. The IBINET project demonstrates the potential of low cost satellite data terminals for a packet network [2]. These are based on the use of spread spectrum techniques and digital signal processing techniques that have been generally used till recently only in expensive military and space systems. Ramani and Miller [3] have proposed a new type of communication satellite for a messaging system for implementation of electronic mail. This is based on a set of four subsynchronous satellites that have on board message switching hardware. With the help of a few thousand low cost satellite terminals, far-flung rural areas can be brought under an electronic mail network. The PACSAT project involves interconnection of amateur radio ground stations and ground-based networks around the world with store-and-forward facilities on a low-earth orbiting satellite [4]. A low cost telegram service can be implemented using such systems for application in less developed countries.

4.2 DIGITAL RF LINKS FOR RURAL EXTENSIONS

In this scheme use of VHF/UHF links with digital modulation is envisaged. Adaptive delta modulation (ADM) provides a means of digital transmission of voice signals over low cost VHF/UHF links [5].ADM has excellent bit error tolerance which makes it ideal for low grade RF channels. This has been extensively tested in an experimental system [6]. In the system shown in the figure, rural concentrators/switches are connected with a central office via ADM trunks. The central office is a PCM switch. Recent developments in signal processing hardware provide as a low cost solution for direct conversion at digital level between ADM and PCM signals bypassing the audio conversion. Intensive work on low cost, low bit rate encoding techniques is in progress worldwide. The present scheme can be easily adapted to incorporate better devices and conversion algorithms. Fig.7.

4.3 RADIOTEX

This is a system for simultaneous communication/broadcast of voice and animated pictures over narrow band channels. Channels of special interest are the amplitude modulated radio broadcasting channels which permit a very wide area of coverage at low cost. The system is especially interesting for those areas where satellite coverage does not exist, or is not feasible.

The scheme is based on the use of standard 5KHz channels. In order to be able to achieve the objectives, fullest use of microprocessor/VLSI technology is essential. Basic features of the system are:

- Use of narrow band AM broadcast channels.
- Simultaneous (or apparent simultaneous) transmission of voice and animated pictures, cartoons, etc.,
- Multiscript text generation and display.
- Long range, around 200 km.

A programme generator and a microprocessor based receiver form the two main components of the scheme. In the programme generator, animated pictures are produced by a graphic processor. A digitizer is used for digitizing pictures or to serve as an electronic blackboard. Voice and data are combined in a mixing unit which is based either on band splitting technique or on time shared basis using silence detection. The microprocessor encodes the pictorial data through a picture description language which achieves very low bit rate encoded output. (Typically 600 bps for the facilities required). Buffer management and error control operations are also performed here. A TV monitor helps in supervision of programme generation. The combined output after appropriate band limiting, is sent to an AM broadcast transmitter for live transmission.

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At the receiver the output of a standard AM receiver passes through a separator circuit which separates the audio and graphic signals. The graphic signals are passed on to a decoder and picture regenerator circuit. This is based on a microprocessor which regenerates the original picture from the received encoded data with appropriate error control. The video output is combined with the audio in a VHF modulator which generates the composite video output to be displayed on a TV receiver. This system will be very useful for mass education. Fig. 2.

4.5 MULTILANGUAGE/MULTISCRIPT TERMINALS

In many countries, it is necessary to have communication with computers in local languages. Although it is possible to develop a separate terminal for each language, it is feasible, in some cases, taking advantage of the commonality of features, to develop a common terminal for a group of languages. Common features like character set, similarity of script and method of compounding could be used for this purpose. Based on this, a system has been developed for Indian languages.

The main problem that has to be tackled is with regard to the generation of characters on hard/soft copy terminals. The unwieldy character set and the graphical peculiarities of any Indian language pose a formidable problem which calls for a unique software approach.

For the first system an algorithm has been developed and implemented for the Devanagari script but could as well be adopted for any other Indian language. The implementation process involves various aspects of

- keyboard layout,
- assignment of code for characters,
- generation of characters, compound characters and
- displaying characters on raster

The system has been implemented by using a standard ASCII keyboard and relabelling the key tops and a dot-matrix printer [7]. It employs standard low cost 6800 family microprocessors. A simple text processor has been implemented. Using the basic hardware, with minor modifications of software, it can be adapted for other Asiatic or Arabic scripts.

Combining this with graphics facility provides a useful tool for machine communication in local languages. Fig.3 shows typical outputs.

4.6 DIGITAL BROADCASTING

This is a low cost scheme for distribution of news. Small news papers in rural areas cannot afford a teleprinter for news. As a result the news content of these papers is quite poor. The scheme proposed here uses standard radio channels for broadcasting news. Information that is normally distributed on teleprinter networks is transmitted with appropriate error control bits appended on radio channel using a modem.

A standard receiver gets the encoded message which is decoded and stored in a microprocessor for display on a TV monitor with keyboard. It can also be printed on-line or stored for later use. Fig. 4. Presence of a microcomputer enhances further the information gathering and processing capability of the news editor.

5. CONCLUSION

Recent developments in component and systems technology provides some interesting solutions to problems of providing adequate communications in the developing countries. Innovations based on systems developed for satellite, marine, avionics and military communication will have a good potential and one has to take full benefit of the work already done elsewhere.

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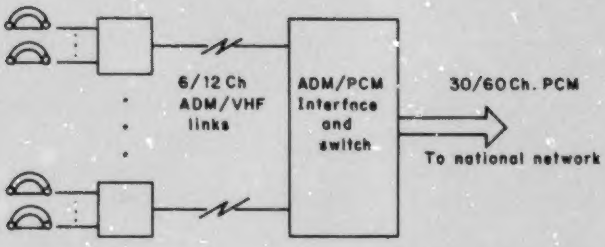
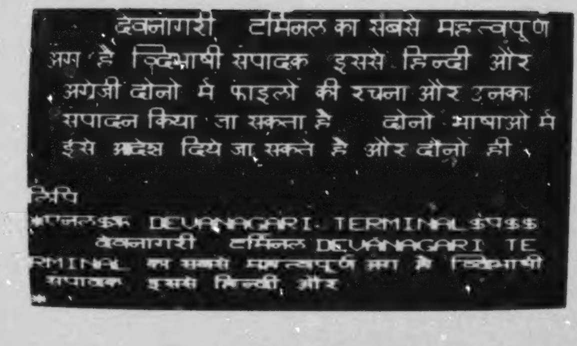

6/12 Ch
ADM/VHF
links
ADM/PCM
Interface
and
switch
30/60 Ch. PCM
To national network
ADM Switch/
Concentrator

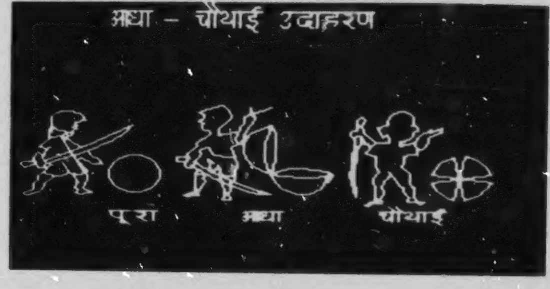
Fig. 1.



```
       देवनागरी  टर्मिनल का सबसे महत्त्वपूर्ण
अंग है द्विभाषी संपादक  इससे हिन्दी और
 अंग्रेजी दोनो मे फाइलो की रचना और उनका
 संपादन किया जा सकता है    दोनो भाषाओ मे
 इसे आदेश दिये जा सकते है और दोनो ही

लिपि
*एनलक्षक DEVANAGARI TERMINAL$P$$
      देवनागरी  टर्मिनल DEVANAGARI TE
RMINAL का सबसे महत्त्वपूर्ण अंग है द्विभाषी
 संपादक  इससे हिन्दी और
```

Fig. 3. MULTILANGUAGE TERMINAL-OUTPUTS


आधा – चौथाई उदाहरण
पूरा
आधा
चौथाई

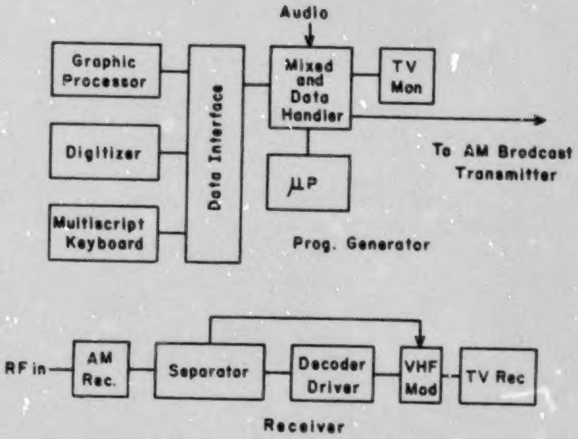

Audio
Graphic Processor
Digitizer
Multiscript Keyboard
Data Interface
Mixed and Data Handler
TV Mon
µP
To AM Brodcast Transmitter
Prog. Generator
RF in
AM Rec.
Separator
Decoder Driver
VHF Mod
TV Rec
Receiver

Fig. 2.

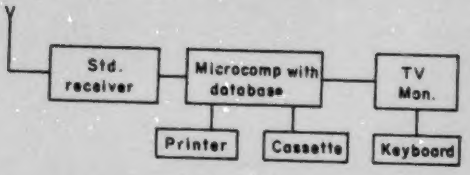

Std. receiver
Microcomp with database
TV Mon.
Printer
Cassette
Keyboard

Fig. 4.

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Biometric Assessment of Mass Communication Audiences with Respect to Indigeous, Native Population

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1. Abstract

Biocybernetic communication assesment deals with the information impact of a film or television show, photographic picture, painting, exhibition, display or any literary or functional texts or verbal stimuli on human being both individuals as well as on groupc (mass audiences). Methodology consists of a series of specific tests - sondages performed by the psychophysiological instrumentation on live persons who receive the media information input.
The information processing perception and storages within the human world is seen as an energetic process with catalythic characteristics.
Therefore, what we measure in biocybernetic tests are enegetic changes in the human body due to the information impact from films, television, radio programs, or generally due to the perception of our informational environment.
In dealing with indigenous audiences, special pre-testing is necessary to establish the biometric profile. This profile may contain an important variable specific to the certain culture or tribe.

2. Biocybernetic Basics of Information Impact Assessment

Under term "information" I understand in a broader sense energetic change with catalythic character. In this sense, information is a basic componenet of every television program, film, theatre, play and radio news. The previous definition is connecting information in media with information processes, going on in and between plants, minerals and animals.

In our world, between human beings, information processes have a specific structure, which I call an information chain. In simple scheme, it has three parts:

Informantion Source	Transmission Conditions	Receiver and his response
(TV program, film, play news	(readers, room cinema-theatre TV set, auditorium exhibition space)	(people, viewers TV watchers)

If you change any part of the information chain, the information itself is changed. For a long time it was believed, that an information source contains all the information itself, and nothing could change it. Now we know, that an information source carries only parts of information, capable to start catalythic process. Sometimes an accidental structure (stone, cloud, view in a street or country) could be an information source. Information sources, capable to start the information chain in most cases of human perception, are called logistic or artistic structures.

Transmission conditions (readers room, cinema theatre, TV set, auditorium, exhibition space or in a broader sense any perceptual environment) was believed to be only a passive pipe, through which a message is delivered on destination, to the people. This exists when information is delivered immediately. The situation could be reversed, if transmission is occuring for a longer period of time (or on large distance or quantities TV programmes beamed through a television set for week or years). The repeated transmission conditions are stimulating a perceptual stereotype, specific for each transmission medium (medium itself may carry important and influential, but never pronounced messages).

Receiver (Viewers, audience of theatre, play or concert, readers) were believed to be a consumer of information source. This is far from the truth. An information source is never physically consumed, it is perceived. This perception could lead, but not necessarily so, to the comparative information processing and retention in the human brain. A quantity of information, its structure or successeion is not the same, as in an information source, and can be, and in most cases is, diametrally different. By retention, only part of the information quantity released from the information source, is factually stored, in the human memory.

By the processing and storing of information in the (viewer's) brain, other processes are happening, which incoming information is starting as a catalyser. In this sense we are witnessing the information impact. This may provoke the receiver's response.

Information patterns and perceptual stereotypes in a certain way are close to the natural process, in which the human eye simplifying any picture falling onto the retina, and after certain simplifaction inputed on the neocortex of the brain.

When many information patterns exists in daily life, less individual contents of its parts are perceived or stored in the memory. When several perceptual generations are living in the same time, as in our time, this process could be viewed as shallowing of previous ideas, contents or themes. Also it influences any theme presented by media which is permitting easy information pattern transfer (television), and build a certain resistance, when presented in media with a low information pattern transfer (abstract-painting). On the other hand, information patterns is allowing a faster transfer of ideas and meanings.

When information patterns are used for longer time and successfully in communication between people, it is becoming a symbol. There is nothing mysterious about any symbol in present or past use. High practicality, easy use, eay fixation in the human memory are basic ingredients of any sumbol. There is a particular way of fixations in visual symbols, which is basic in following a physiological characteristic of an eye and its extension through the visual nerve into the brain. The audio symbosl were highly fixed in speech and in a certain tune, music.

The base for understanding the information transfer between people is the mechanism of sensoric inforamtion perception, and information processing in the human body. Here, psychophysiology give most of the leads in contemporary information design.

3. Methodology and Instrumentation in Biometric Assessments:

There are three kinds of energy changes measurable in bioinformatics:

1. thermal changes (changes of body temperature)
2. electrical changes (EEC)
3. chemical changes (chemospectrographic)

Any of these changes can be interrelated at any time, with the time axis projected into each.

The interval between the changes at the same level is called biometric potential. So when you see the graphical records of certain variations the peaks and lows in it are the record of these potentials. They correspond to the energetic processes in neuron systems, are activated via information input, processing or storage, and also many other processes not in connection to bioinformatics.

This process is very far from simple interpolations. Therefore if you see a big, large potential on the recording, it may not correspond in the interpretation ot the same extent of the impact or vice-versa. Quite sophisticated diagnostics have been developed over the last forty years; from quantitative, comparative analysis to analog-digital 3-D Fourrier analysis of biometric data.

Also, information interception, processing and storage of information stimuli like film and television programs, are not seen as a static or only a quantitative impact - quite opposite, it is a dynamic, systematic process (matrix) which succeeds the actual time of the program presentations, and continues in addition to parts of the program reflected in the human mind, or other (subjective or individual) elements.

So far as we know, biometric research provides an unusually deep and precise tool for insight into the human bioinformatics.

Basic laboratory could test a variety of stimuli ranging from simple photographs, posters, films, TV programs, literary texts, scripts and stories, as well as actual documentary and news material.

For measuring the information impact of films and television programs on the human mind, the biometric laboratory consists of:

1. Sensoric scanning devices (electro-oculograph combined with electro-retinograph audiometer with audiospectrgraph).
2. Cortical processing devices (electro-encephalography with electrochemospectrograph).
3. Control feedback devices (electromyograph, electrocardiograph, GSR and BSR monitoring channels, ENTG monitoring channel).
4. Registering devices (data-graphs, x-y plotter, polygraphs, digital converters).

This set-up is a basic one, and it could have many instrumentation variations.

For diagnostic purposes, the following devices are essential.

1. PDP 11/25 computer
2. 16K of core memory
3. AD-01 analog to digital converter
4. AA-11D digital to analog converter subsystem with scope control unit
5. Textronix 613 storage tube display
6. TC-11 dual DEC tape drive (or RK-05 disk)
   For programming service we employ:

   DEC RT 11 operating system with system program

DEC BASIC RT 11 interpreter

Graphic display routine for BASIC RT 11

Generally, there could be a theoretical division emphasis in the research of information source, transmission conditions and receiver feedback. There could also be technological differences or methodologies when searching for the visual, audio, or audio-visual input. Finally, there is a significant difference between the test subjects.

In praxis, all those aspects are present, when complext tests are conduected.

There are several basic laws, which must be followed in order to understand and practically sue the tests results:

1. I presume that every person receiving media input is different, spedicific, and could have a specific biometric responses.
2. I presume, that transmission conditions could change the form and content of the same input.
3. I presume, that the results of tests by all the exactness must be of synthetic, cummulative character containing also the parts of the information which has little or no relationship with measured input.

Therefore, the follwoing methodological rules must be observed:

1. Before a test is made, a precisely programmed pre-test is a must.
   This is a key for further diagnosis of graphical tests results. The stimuli for the pre-test must be as natural, as simple, and as smiliar for all tested subjects.
2. Any change, observable in the person's external behaviour must be recorded on the test, as any change, made by the instrumentalist in adjustment during the testing periods.
3. The recorded test should be verified by a battery related questions, and coded on a test strip. If the verbal and direct sensory tracking conflicts, the test should be repeated.
4. All tests should be read comparatively, cued by the time log of input. Any test in biometric communication research could be made on a single, or multiple channel biometric tracking equipment. Generally, if we use tests for pre-production searches, multiple channel tracking is the best mode. During the media piece production (film or television production, exhibition instalations), single channels could bring specific answers to the artists. For finished media products, once more multiple channel recordings could answer most questions of information impact.

Specific tests:

A number of specific tests could be performed either on the materials for the selection in media pieces (films, TV programs, display), or o n the finished artwork.

1. General Readability (or Input) Test:

This is the tests, where we run the series of materials (pictures, recordings, film shots, TV sequences) for the selected sample of audience. It is the easiet test, and also the fastest one time of the test is the same as the time of the artwork performed.

Several points should be observed:

a. During the pre-test, the stimuli or signs should be relevant to the borders of the sensoric fields or ranges.

b. The test should immediately (till 2 minutes time) follow the pre-test.

c. When the initial input channel is steadily diminishing the activity, signifying the fatigue of the test person, the test should be stopped and re-run.

In the diagnosis, not the isolated input curve, but the envelope curve is significant. It shows the general input, general processing and parts (times) of media pieces called "domains".

2. Decision (Selection) test:

This is the test, where we search for information "domain" part of a picture,(specific shot in a film, sequence in a TV program). For this, after the general readability tests, the "domain" test could follow. It consists of a performance of an isolated information piece with a short pre-test and a post-test period. The result should be related to the first test.

If comparable, the strength of the information domain lays in piece itself. If there is a relative difference, the information impact has a cumulative character.

3. Basic Media Tests (colour, movement shape):

Those three sub-tests are performed, if we are searching for the specific information impact of a certain colour, a certain shape in a picture, or a certain direction or speed of movement in the picture. If all three tests are working with real or stimulated input, the measurable impacts are related back to the test No. 1 or to the pre-test, with similar stimuli.

4. General processing test:

This test is geared toward the information formative judgements, of no value for the majority or receivers (mistakes of most film and television and juries festivals). Each medium has also its geneology of perception. In the beginning, with the first appearance of a new medium, the semantic part of information is becoming understood, and when those semantic parts are becoming too easily understood, after long exposure to the medium (film, television) the formal parts once more are closing this eclipse with high importance for the receiver.

The same cycle is happening, when time base is introduced in any medium by execution to the theme: When the theme is presented too slow, the small, sometimes unimportant formal details carries of messages; when presented in comfortable speed for perception, semantic characteristics are becoming most important; when presented too fast (faster, than average perceptual speed) the content of the message could become unimportant, leaving only external formal parts as carriers of a message.

Knowing the role of time and space in information chain, it becomes visible, that the creator of information sources could not alone outline all the characteristics of the source, not knowing the perceptual spectrum of the audience. This does not mean, that the artist must be on the tail of the audience, fullfilling all their wishes. But respect for the information chain assures the artist the success of his projected art work. (This plays similar roles for business or political information chains structures).

Inside the information cascade, the structure of time is becoming important. When placing important messages into one time unit, it should be assured, that in that time most of audience is perceiving actively and are putting this information unit on a high place of importance.

There are several basic facts, influencing the structure of time in any information chain:

1. The basic (metabolic) perceptual rhythm:

The human perceptual system has the periods of high operation sensitivity, and periods, where due to the metabolic changes, the functions of sensors or channels are slightly subdued. This is happening (with great deviations due to age, physical activities or imposed neural activities) approximately twice per minute. Children could have even three or more periods, older people could have one or less than period per minute.

2. The imposed perceptual rhythm:

The previously mentioned basic rhythm could be modulated due to the input of information from the information source or environment. The artist could fasten or slowdown the natural rhythym to a great extent. To do this, a certain time is always elapsing (of several minutes). To accomodate a person on a certain unusual perceptual rhythm, it takes for a single sesoric channel sometimes 10-15 minutes (overtures in operas), for multiple channel delivery 2-5 minutes. To change imposed rhythm it takes a much shorter time, but always this change goes over the one or more periods of natural perceptual rhythm.

3. The stress (oscillated) perceptual rhythm:

When using catalysts creating stress waves in the human brain of the perceivers (or "emotional" impact), it could happen, that the perceptual rhythm is irregular, with returning irregularities during short periods. This situation could create a "bouncing" effect, even if external stimuli is not present (we could add in mind a certain dialogue, actor, situation even if they are not present on screen).

The perceptual rhythm is factually changing the information source parts (without anything changed in film, painting, photography, television program.) This process is causing much of the so called "subliminal effects" in tightly programmed media pieces (TV advertissements)

When the information environment is supplying the person with many information in a short time, people start to join them together. This joint information is dialectically becoming a new quality having a different content, sometimes, in no connection with those previous contents of the parts. Large joints of information are called information patterns (those may evoke qualitative different responses from same sources)

(Example: You are driving on a highway at a low speed through suburban of a town - you can distinguish every house. At high speed you perceive the same as housing entity. You are now unable to perceive detail features. One of those houses has a tower, you consider ugly. When driven through at a high speed, you may retain the memory of only this ugly tower, skimming over many nice features of houses without retention. Similarly this could happen in television programs, where certain shots have a very positive value, but the audiences skims over and retains only negative details, because of the position in successive speed. So is developed pattern of the country, of cars, of women and many others. This pattern stays for a certain time in the human memory, the specific parts of patterns decay, leaving only the indispensible features of it. This simplified pattern is called perceptual stereotype. For evoking such a sterotype, a minimal amount of distinguishing signs is necessary. (Example: in oval stones we could distinguish a human face, in a tree during fog human posture, in black dot on a highway an automobile.) Inforamtion patterns and perceptual stereotypes are shaping taste and fashions of media audience. Both are an inclination of large segments of audience to distinguish the shapes or situations easy and fast with their memory or sensors.

This response could be a latent one (on a meta-level) or a pronounced, behaved one. It could also start another information chain.

An information chain is existing in a certain time The time of information production and information perception has different axis.

Production time is very well known in media, (time necessary to produce, organize or structure certain segments or complicated information), as well as transmission time (the airing time in television, screening time for film). The least known is a perceptual time. It is commonly belived, that the time of transmission or performance should be identical with the time of information perception. Even if it seems to be in common understanding in human communication modes, it is not.

The time differences are in the seconds range. In older times, those time segments had little or no meaning. But, with the development of large successive complexes of information (film, play, television programs), those perceptual delays are causing the overlaps of information. When one information quantum is processed in the brain, the other could not be processed in the same range or intensities. Even if the short term memory could delay certain quanta, the constantly incoming information is more and more overlapped.

The overlaps in information processing are typical for information complex, called the information cascade. There are two different kinds of information cascades: one, when the perceiver (people) had their own freedom to perceive one piece, part of information after another at their own pace (exhibition, gallery, book). This I call horizontal, linear cascade. Usually, there is a great freedom of the perceiver not only toward individual perceptual time, but also toward the freely chosen succession of pieces. The second information cascade is typical by fixed, programmed succession and time for perceiving of pieces of information which I call vertical, structural cascade The high overlaps are typical for vertical information cascade. Each piece of information (scene shot, sequence) is perceiver in time, called perceptual time, varying with different groups of people, a different city, country, age or century.

There is an important geneologic and histologic phenomenon in perceptual time speeds. During the space of human life, a person perceives everything with different speeds and different manner. Also, during the centuries the perceptual time had changed. People in 1470, 1880, 1920 and in 1973 were perceiving their information worlds with different speeds. I would say, that in contemporary time, the speed of perception especially on the American continent, is the fastest one has ever known. This, of course, does not mean that all the perceived informations are fully processed and stored. But, in a certain sense, nowadays we are living more, than one perceptual life generation span. Compared to the fourteenth or seventeenth century, the contemporary man is living five or seven perceptual live spans during his/her own life. This may be one factor in the complex called generation gap, or the complaints that a son cannot understand his father's conception of life and ideas (if the father is perceptually his great-grand father).

If we know the perceiver's way of information processing and storing, the complex of all his habits and approaches toward information we could call perceptual spectrum (mass media audience)

The perceptual spectrum of audience is varying with time and space. The human environment, culture and history (tradition) is influencing highly the way people are perceiving the world. The similar environment, culture, tradition could group the individual perceptual stereotypes into a common way of perceiving. This process is basic for the development of mankind. In tribal societies, man had fixed first information stereotypes (ecologic stereotypes of ways for hunting, tool production), develped highly fixed stereotypes (language, alphabets) and, coming toward the highest development in his environment, culture and traditions, diversifies those lengthy and costly developed codes.

In this sense, we are now dealing in mass media with highly diversified audience. No longer is it true the "average viewer", or "average profile" of television or film audience. Very small groups of audiences are differing in habits of perception and only in very high abstract (not necessarily the same) are joined together and understood as common signs. We are now dealing with "multi-layered perceiver", each has layer of mind with different specification of interests, preferences in time (no longer the prevailing "prime time", and specificities of place, country, town). The diversification of transmission centre (cable television) is speeding up this process. The same has happened in exhibitions, museums, galleries. In those field designers had developed a specific way, how to attract this "multi-layered visitor" (multi-media exhibitions, multi-programmed galleries and museums) to the information source.

When the receiver of information has the multi-layered characteristics, it becomes difficult or impossible to transfer one information source from one place or group receivers, to another. The same information source is understood quite differently in different places or for different groups of people. The logistic understanding (what story or theme or artwork is about) becomes less meaningless for people with different perceptual stereotypes and spectrum. The most misleading things are happening, when some people tear out the information source (film, TV program, painting) or its part and put it in a separate, isolated place, then start to judge the values of it. Finally, this is coming toward the plain processing of certain stimuli. It should be combined at least from two channels: one, containing particular sensoric input tracking (audio, visual): the second, from EEC recording on particular parts of the neocortex. Diagnosis could be done either on binar decision mapping, or on a particular part of the information (picture, sound). If a part recognition is in search, a plotter should be added to the sensory track.

5. Stress Wave test:

This test is done if we are searching for stress wave developmet during the processing of information. It should consist of sensory input tracking (ev. plotting), EEC channel and in time - synchronized the EKG channel. The electrodes should be on the main veins of a small circulation circuit, with ground on chest part. When recorded - the part of the information input, the stress wave is immediately visible on EKG strip, within the 1-2 sec. range from the input. The intensity will vary highly from person to person. The length of the impact could cease within a few seconds, or could be prolonged, in diminishing curves, for a longer time, even without any further input (bouncing stress waves).

6. Reaction tests:

These tests are performed, if we wish to know the person's reaction or desire to feed-back on the information input. It consists of a sensory track, EEC and EDG plugged as control channels, and EMG and GSR as main recording channels. EMG channel has significance for immediate responses, the GSR for cumulative responses.

4. Specific problems related to indigenous audiences during biocybernetic testing

There are several levels of differences, when working with biocybernetic laboratory in the environment where people are not accustomed to the instrumentation and testing methodologies.

1. Distraction elements of instrumentation

Here the test subject is usually curious and alert to the instruments and operator. The distraction effect is most visible on pre-test and could be alleviated in most cases by friendly explanation of the instrument and by example (operator wear electrodes or harness by himself when explaining the function of the apparatus.) The duration or overcoming of the distraction is easily diagnosed on GSR recording channels.

2. Concentration differences

In many cases, test subjects had difficulty to concentrate their attention on the video screen and occaisonally they moved their bodies involuntary. Those segments produced unwanted noise in ECG channel. Despite several efforts to calm down the subject, there is really no way than to eliminate the parts of the ECG signal associated with involuntary motoric movement from further diagnosis. A very important feature is to instruct the operator to activate the time marker of the datagraph, whenever the test subject moves.

3. Differences in formative percetions:

In some cases, test subjects react vividly to the external formative features of performed television programmes (staging of Z-axis of shots, zoom-in, zoom-out, pans and tilts)! Diagnostically those reactions had unusually long persistence and influented significantly the content of television shows biometric record.

4. Difference in semantic variables:

Perhaps most significant differences were experience in semantic judgements by test subjects in the real -time biometric records and in the retrieval time, when recalls to the show were activated. Here, indigenous test subjects were showing very different signal patterns and different recall mechanism - leading to the judgment of a different content of a show or different combinatory thinking.
In the scanning of imaginatory biometric potentials the majority of text subjects had a rich pattern of memory searches (on EEG signal) but less active memory storages Formative elements storages had prevailed above semantic ones.

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SYSTEMS ENGINEERING CONSIDERATIONS IN THE MODERNIZATION OF NATIONAL TELECOMMUNICATIONS NETWORKS

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1. Abstract

Nations of the Pacific hemisphere have shown an increasing interest in the use of digital technology to modernize their national telecommunications networks. However, evolution to digital networks will require a systematic planning and procurement strategy on the part of the telecommunications administrations if maximum benefits are to be achieved and misguided procurements or other costly mistakes are to be avoided. This paper discusses some systems engineering considerations to be kept in mind when considering the incorporation of digital technology in national telecommunications networks.

2. INTRODUCTION

The emergence of improved digital switching and transmission technologies, as well as the prospect of being able to provide integrated services over a common digital network, has led a number of Pacific hemisphere nations to consider the role that digital technology might play in their national telecommunications networks. In fact, several nations have already taken the first steps in the evolution to national digital networks.

The questions of whether, when, and how to incorporate digital technology into national networks are not easily answered. User needs, major system alternatives and their associated costs and risks, the difficulty in transitioning from the existing network, and many other factors have to be considered. An orderly approach to the planning and procurement of digital systems will be required if efficient networks are to be developed and costly procurement mistakes avoided.

The objective of this paper is to present a systems engineering approach that can be followed by telecommunications administrations as they consider the incorporation of digital technology into their network.

Following these introductory remarks, Section 3 defines a systems engineering approach to telecommunications system planning and implementation. Section 4 describes the system acquisition process in detail, focusing on some special concerns related to the implementation of digital networks. Section 5 offers some concluding thoughts.

3. THE SYSTEMS ENGINEERING APPROACH

The acquisition of a major telecommunications system can be a difficult undertaking under the best of circumstances. Often, however, the acquisition process takes place in a context of ill-defined or inconsistent user requirements, budgetary constraints with concomitant pressures to procure the system for which the most favorable financing can be arranged, overdependence on vendors for technical support in establishing system design and equipment quantities, and so forth. All too often the result is a procurement plagued by one or more of the following:

- o Delays and cost overruns
- o A procured system that is difficult to operate/maintain
- o A procured system that does not work

Systems engineering offers a means of reducing the incidence of such unfortunate procurement experiences. The systems engineering approach begins with the definition of requirements and ends with the installation, validation, and successful operation of the procured telecommunications system. The importance of a systems engineering approach is that it provides an orderly process for acquiring a telecommunications system that satisfies user requirements in a cost-effective manner.

There are a number of steps involved in the systems engineering approach to system acquisition(1). The main steps include the following:

1. User needs determination and requirements formulation
2. Development of the system design
3. System acquisition planning and preparation
4. Procurement of system elements
5. Deployment and test
6. Transition to operational status

Each of these steps will be discussed in detail in Section 4.

There are two points that should be made with respect to the system acquisition process.

First, the telecommunications administration needs to be actively involved in all of the steps if the system is to be successfully acquired--that implies the need for adequate resources (personnel, technical and management expertise, and money). If adequate technical expertise is not available within the telecommunications administration, it may be necessary to contract for outside technical support--preferably from an organization that does not sell the type of system being acquired.

Second, it is important to note that a great deal of work should be done before proposals are solicited from industry and a contractor is chosen. Inadequate preparation prior to the procurement phase can lead to the solicitation of proposals for a partially defined system, leading to cost overruns to meet the desired system requirements.

4. THE SYSTEM ACQUISITION PROCESS

For an application of the systems engineering approach to a telecommunications system acquisition, consider the case of a telecommunications administration that wishes to modernize and possibly expand its telecommunications network. It is aware of the worldwide interest in integrated services digital networks (ISDN), but is unsure whether digital technology should be incorporated in its modernized network. Indeed, it has no firm idea of what form its modernization effort should take; it does know, however, that its existing network is inadequate.

To develop and implement a cost-effective modernization program, the telecommunications administration needs to undertake the systematic planning and acquisition process outlined in Section 2. The activities to be undertaken in each step of that process are described in the following subsections.

4.1 USER NEEDS DETERMINATION AND REQUIREMENTS FORMULATION

The determination of user needs and the formulation of system requirements are two of the most important elements of the entire telecommunications system acquisition process. Without an agreed-upon understanding of whom the users of the modernized network will be and what requirements must be met by the network, the likelihood of winding up with a telecommunications network that is neither cost-effective nor appropriate to the real needs of the users is high.

Examples of the types of questions to be addressed during this phase include (but are not limited to) the following:

- What are the current and projected locations of the users?
- Will the network be shared by military and civilian users?
- What is the projected growth in users?
- What are the current and projected voice and data traffic levels?
- What interfaces with international networks are required?
- Are there any special capabilities the network must have?

Answers to the questions will help to determine the required scope of the modernization program and will lead to an agreed-upon set of requirements to be used in all subsequent design efforts.

Formulation of the requirements, coupled with the description of the existing telecommunications system, will allow the administration to explore alternative systems concepts for meeting the requirements. These concepts can range from minor modification of the existing system to the complete replacement of that system. For the case of the telecommunications administration considering (but not committed to) the incorporation of digital technology in its network, the number of potential alternatives is large. The administration could keep its analog telephone network (perhaps supplemented by radio links) and replace outdated functional elements with new versions (for example, replace step-by-step switches with crossbar switches). Voice and data traffic would share the same network. Another possibility would be to install digital transmission and switching facilities, while keeping the local subscriber loops analog. Provision of separate voice (analog) and data (digital) networks would also be an alternative, as would an integrated digital voice and data network. Geographic constraints might require satellite or HF radio technologies to be overlaid on each of the terrestrial network alternatives.

Tradeoff analyses of the concepts, including assessments of life cycle cost, technical risk, flexibility for future growth, and so forth will be necessary. The end result will be the selection of one of the alternatives as the concept to be used in all subsequent acquisition steps.

Once the requirements and system concept have been determined, an overall schedule for meeting the various requirements will be devised. If, as is likely, a phased implementation is envisioned, the required operational capability at each phase will have to be specified.

4.2 DEVELOPMENT OF THE SYSTEM DESIGN

The next step in the system acquisition process is the development of an overall telecommunications network system design based on the agreed-upon set of requirements and system concept. The system design will need to integrate requirements in each of the following areas (2):

- Switching
- Transmission
- Network Control
- Signaling
- Numbering Plan
- Topology
- Routing

Detailed design issues will be dealt with during this phase. For example, if it has been decided to employ a digital transmission system, a number of items will have to be specified. The modulation technique (e.g., pulse code modulation, delta modulation), the framing structure, the allowable level of idle channel noise, codec requirements, the multiplex hierarchy, the line rates and codes, and so forth will all be defined as a result of analyses conducted in the system design phase. Similar issues will be addressed for the other areas.

Two other activities to be undertaken during the system design phase are the development of an operations plan, which will describe how the modernized system will function, and the development of a tariffing plan to be implemented after the system becomes operational. The tariffing plan, in particular, will require close coordination within the government.

4.3 SYSTEM ACQUISITION PLANNING AND PREPARATION

Once the system design for the proposed telecommunications modernization project has been developed, it is important that the activities necessary to turn that design into an operational system be planned. These activities typically will include the following:

- Overall program management
- Procurement of system elements
- Staffing and training
- Logistics and maintenance
- Facilities and site preparation
- Installation, test, and transition

The plans for accomplishing each of the activities will be summarized in a Master Plan. More detailed plans will be developed during the procurement phase by the administration or outside contractor(s). The Master Plan plays an important role in coordinating the activities of all of the organizations involved in the modernization program.

Another task that would be undertaken during this phase is the preparation of detailed specifications for each of the subsystems. Such specifications would contain information on standards to be followed and interface control documents to define the interfaces between each subsystem. These specifications will be based on the results of the system design phase, and will be important inputs into the procurement phase.

4.4 PROCUREMENT OF SYSTEM ELEMENTS

Only after the activities in the previous sections have been accomplished is it appropriate to undertake the procurement of those system elements (e.g., switches) that the administration has decided not to develop in-house. For the procurement process to be effective, however, it is important that it be well-planned and efficiently executed. Thus, procurement documentation needs to be developed for the bidders: specifications, work statements, instructions for bidders, and so forth. Next, selection criteria will have to be prepared for use in evaluating the industry bids. A set of meaningful, objective criteria will help to prevent situations in which a particular vendor's digital switch, for example, is chosen because of attractive financing provisions, even though it does not satisfy critical system requirements.

After the bids have been evaluated, contracts will have to be negotiated. In addition to price, the telecommunications administration will need to be concerned with questions of provision of training, spare parts, software maintenance, technology transfer, and so forth. It is during the contract-negotiation phase that the value of having done substantial planning and design work becomes evident; any item not considered prior to the signing of a contract will become an expensive contract modification, so it is important that the administration do its requirements formulation and basic design work before, rather than after, the contract is signed.

Finally, the telecommunications administration will need to monitor closely the progress of the contractor(s) throughout the procurement. Effective monitoring of contractor performance is critical, of course, but may be difficult for a telecommunications administration to do with its own limited manpower. If technology (for example, that contained in digital network components) is being procured that is not familiar to the technical staff, it would be wise for the administration to hire an outside organization to provide technical support. In addition, if many contracts for pieces (e.g., switches, network control facilities, microwave transmission facilities) of the overall network have been let, it may prove wise to hire a systems integration contractor to be responsible for making sure all of the elements come together into a viable network.

4.5 DEPLOYMENT AND TEST

As the contractors deliver the various system elements, installation and checkout will need to be done, most likely on a phased basis. Subsystem testing should be followed by system-level testing to ensure that the performance requirements have been met. Although the system acquisition effort up to this phase may have incurred delays and cost overruns, it is important that the telecommunications administration not try to shorten the planned testing activities in an attempt to save time and money--it would be false economy.

4.6 TRANSITION TO OPERATIONAL STATUS

After the network elements have been installed and tested, they should be transitioned to operational status. It is important that a detailed transition plan be developed early in the procurement phase and that it be followed carefully. Unreasonable service disruptions during the transition can jeopardize the acceptance of the new technology by the users.

While transition is taking place, personnel will be familiarized with the system's operational procedures. In addition, any system shortcomings will be identified and corrective plans made.

5. CONCLUSION

The preceding sections have outlined the activities that a telecommunications adminstration seeking to upgrade its national network should undertake. There are, of course, more detailed levels of planning and technical analysis embedded in these major activity areas, but the basic approach to be followed in telecommunications system acquisition is as presented. It needs to be stressed that a successful telecommunications system acquisition will require much more than a simple procurement effort--a great deal of work before and after the procurement decision is made will have to be done.

Finally, no system acquisition takes place in a vacuum. Political and financial considerations have a habit of intruding on large-scale telecommunications modernization programs. Nonetheless, a well-structured system acquisition program will help to minimize the harmful impacts of such intrusions and to assure that any changes are consistent with the long-term objectives of the modernization effort.

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IMPACTS OF AN INTEGRATED SERVICES DIGITAL NETWORK (ISDN) ON THE FLOW OF INFORMATION IN LARGE CORPORATIONS

by Bruce Kin Huie
with assistance from
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Within the new environment of the telecommunications industry, it is apparent that the concept of an Integrated Services Digital Network (ISDN) will play a central role in information processing. ISDN is a concept for a digital network which can ultimately carry all types of information such as voice, data, and image over the same physical components. The benefits of this new technology could mean less costly, more efficient switching and transmission for network carriers. But, for major corporate users it means new services and access to all telecommunications services through a standard physical interface, the twisted pair telephone wire.

The first step in the evolution of an ISDN, from the conceptual theory to a technological reality, will be accomplished through the creation of widely accepted international activity, which is coordinated by a committee of the International Telecommunications Union - The International Telegraph and Telephone Consultative Committee (CCITT). The committee is composed of representatives from network carriers and equipment manufacturers from around the world. The release of a set of ISDN standards is crucial to both suppliers and end users of information processing networks.

Today there is a measure of global recognition for an ISDN already. Some carriers are already building and some computer and communication equipment companies are ready to offer products which will link to the ISDN. What can large business corporations expect from an ISDN? A few expectations would be simplicity when accessing communications networks, higher quality communications and better efficiency. Thus, it is a significant concept to business around the globe since many business opportunities result from the accuracy and timeliness of information.

This paper will examine the impact of an ISDN on information processing within the framework of large corporations. The lack of consistent and in-depth research on ISDN impacts does limit a precise definition. The focus will be to provide a platform of discussion on business impacts, how this technology affects the introduction of new end user products and interfaces, and finally the areas of impact resulting from an ISDN. The format of discussion will address the following questions:

- What will be the components of an ISDN?
- Where have carriers started to build an ISDN?
- What products will be supplied to end users to connect equipment to the networks?
- and, How will this technology impact information processing?

COMPONENTS OF AN ISDN

An ISDN is a collection of networks today. The one distinctive attribute which differentiates it from other networks is its digital nature. Most networks today are analog in nature. Analog networks process information by breaking down the signal into a sine wave based on the strength of the frequency. Digital networks break a signal into bits of information with a value of 1 or 0. Much like the way computers process information. Digital processing is faster and cleaner than more traditional analog because the information does not have to be regenerated as often. In addition, more intelligence is built into a digital network than the solid-state electromechanical analog network. This common denominator thus allows information to pass through the same interface and utilize different networks such as voice or data networks, X.25 subnetworks of low speed services networks.

The technology leading to any ISDN standards emphasized the need for certain channel structures and access capabilities for end users in this digital environment. Strong indications lead many in the industry to believe that a 64 Kbps channel will become the standard for network transmission. This would include message oriented signaling channels and information channels which would carry voice, data, image, etc. ISDN thus becomes a high speed channel with emphasis on end-to-end digital connection. It uses common channel signaling and integration of voice and data communications as the foundation to network integration.

INTRODUCTION OF ISDN

Examples of public network introduction of an ISDN concept come from Germany, Britain and Canada. Japan is currently studying the concept of value-added networks for voice and data communications. In each case, the need has arisen to offer transmission services operating at higher speeds than analog transmission facilities currently now offer. While each may not embrace a total ISDN, all have taken a step in the direction.

Germany

The German Federal Post Office (Deutsch Bundespost) plans to set up a circuit switched 64 Kbps network in its Integrated Text and Data Network (IDN). The Deutsche Bundespost plans to pursue:

- Promoting services within the 64 Kbps network which will promote new ISDN services;

- Try out how new network modules interwork and accelerate the development of the ISDN;

- Establish the ISDN on a step-by-step basis in order to acquire technical and operational know-how.

The implementation of the 64 Kbps network will focus planning on using as many network modules or planned modules as possible. This means the design, electrical and program-related componenets and features will be matched to the existing transmission and switching system. The potential for integration of future services will be based on this guiding principle.

Britain

British Telecom (BT) is planning to offer an ISDN pilot carrying data, voice, text or any digitized information at rates of up to 64 Kbps in London's "city" business center. The service will be called Integrated Digital Access (IDA). It will link with Britain's growing digital trunk network. This is a program to install two million digital public exchange lines in Britain which has begun and is planned to be completed in 1988. The ISDN links with this planned network will allow end users the ability to tap both IDA and the public packet-switching and videotex services. Use of IDA lines includes network terminating equipment which is planned to be installed on customer premises to convert existing twisted-pair telephone lines into facilities of the local public exchanges to carry mixed digital data. Each line will carry one 64 Kbps voice or data channel and two 8 Kbps channels, one for simultaneous data and one for signaling.

Canada

Telecom Canada, a consortium of the nation's largest telecommunications carriers, has chosen ISDN as a concept to guide the evolution of its national network. Canada now has the world's longest all digital long distance voice network. The network is a combination of sub-networks, which include: the public switched telephone network; Datalink; Dataroute network; the packet-switched datapac network; private line systems; and the broadband network for radio and television.

PRODUCT OFFERINGS

As transmission facilities are slowly evolving to meet the demand for voice and data communications, a market for terminal equipment and device interfaces has begun to slowly emerge also to meet this demand. It is becoming apparent that driving the demand are the principles of connectivity and integration. Equipment in the office today connects to the existing networks via four-pair telephone wires. The creation of an ISDN in many countries will require new links to utilize existing equipment and interface with future products planned for the office. The integration of existing equipment and facilities should allow the implementation of any ISDN compatible equipment now and in the future as products evolve and new ones are introduced by equipment vendors.

On new product being offered to meet the challenge of new transmission facilities is a Digital Multiplex Interface (DMI). The device is offered by AT&T Information Systems, with licenses by Wang Laboratories, Hewlett-Packard, Honeywell, NEC America, Mitel, Data General and Rockwell International. It will provide connection between two major devices existing in many facilities today - the computer and the PBX switch. Digital connection between these two traditionally separate entities is accomplished by T1 transmission facilities (1.544 Mbps) which provides 23 data channels and one signaling channel operating at 64 Kbps. A DMI provides the means of supporting switched access of EIA-interface standard equipped data terminals to a local host.[1]

In the United States and Japan this will allow 23 terminals to simultaneously connect to a host computer over two twisted pairs of wires. Thus it reduces the cost of interfacing a PBX and a host computer by utilizing an alternative to multiplexer implementation, it remains consistent with the evolving ISDN standards and slows access to a host computer from terminals connected to the PBX switch.

New terminal equipment offered today includes integrated voice-data workstations such as Cedar and Juniper by Rolm, which combine a stand-alone computer with a multiline digital p[illegible] used solely on Rolm's CBX product line. AT&T Information System offers a Business Communications Terminal (BCT) which combines a data access terminal with a telephone for use on its System 85 and System 75 digital telephone switches. British Telecom will offer two versions of end user equipment, both made by Plessey Telecommunications and Office Systems, Ltd. and GEC Telecommunications, Ltd. The first version is a terminal with a built-in telephone, display and keypad using one socket - either X.21 or V.24, both for handling synchronous data at speeds as high as 64 Kbps or asynchronous data at rates up to 9.6 Kbps (with 2.4 Kbps traveling on the 8 Kbps channel). The second version is primarily for office use. It is a box with six ports for various digital and analog gear that contend for the 64 Kbps and 8 Kbps channels.

IMPACTS ON INFORMATION PROCESSING

Operation of an ISDN will affect communication of voice, data, and image within four areas: content, cost, volume, and accuracy. Assessment of the impact in each area will predicate itself on the ultimate competitive edge an ISDN will bring to strategic resources of a corporation. The digital nature of ISDN allows the transmission of numerous types of information - voice, data, and image over the same physical components. Thus a business can lease or buy network facilities which can transmit all current forms of information. This can then lower the cost of network transmission overall, by relying on one physical component versus the two or three used today. Since the content will broaden and the cost will become lower for transmission, it is reasonable to assume, following the theory of basic economics, that the volume of information should increase respectively. This notion plays an important role in network planning. The volume impact of an ISDN will require network carriers to increase the supply of facilities or develop a technology which will increase the capacity of existing facilities (e.g. optical fiber). Lastly, an ISDN will greatly affect the timeliness of information. Higher speeds of transmission allow information to travel faster over network lines. Thus, the accuracy of the information should increase as a result. This impact will be important in industries such as finance, transportation, manufacturing and production.

SUMMARY

It is not the intention of this paper to predict all the impacts of an ISDN within corporations. Rather, it is more to open a discussion of the present state of digital networks and the impacts which can result on business opportunities. As the economics of the Pacific region and the world move to rely on communication networks to tie business much closer together, unique opportunities arise as a result of this new information technology. Mr. F. Warren McFarlan, a professor of Business Administration at the Harvard Business School, has explored this insure in great depth. His most recent article in Harvard Business Review, May-June 1984 titled, "Information Technology Changes the Way You Compete", offers a glimpse into areas where a company can "use this technology, for example, to build a barrier to entry, to build in switching costs and even sometimes to completely change the basis of competition."

Opportunities in different markets represent unique corporate resource allocation decisions. Multi-national corporations have a major role in the future use and development of information technology. The impacts of ISDN on content, cost, volume and accuracy of information can influence the competitive edge in any business.

NOTES

1. AT&T's Proposed PBX to Computer Interface Standard, Data Communication, April, 1984.

Tuesday, January 15

Using the Channels

"Data Communications Standards: The International Issues and Challenges in the Emerging Digital Environment"

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Data communications standards are a significant factor in the emerging digital environment. Activities like ISDN are at the center of the international issues and challenges which need to be resolved to make the "Digital World" a reality.

I congratulate the organizers of the PTC Seventh Annual Conference. The theme is "Toward a Digital World," a most timely and necessary topic for this forum. We are now living in a world that not too many years ago was unimagined even by the most imaginative.

When Man first struck upon the principles of the lever and the wheel he extended his physical capability beyond any limits that he could possibly foresee at the time. That was because he could not possibly at the time of their discovery anticipate all the uses for these new tools. It took a lot of users to push out the horizons.

But now Man has done something much more profound. With today's microchip technology and communications capability he is now able to harness the knowledge of the finest minds and make their genius available at all points on earth. This virtually limitless extension of Man's mental capabilities will be bounded by only two things. The first is the imagination and creativity of those who use these new tools and the second is the rate at which they can have access to them. That is the timeliness of your conference--to bring together industry leaders, government officials, users, and academicians for an interchange of ideas on issues so that together we can open up hitherto unimagined frontiers in the extension and application of the human intellect, particularly in the emerging digital environment in which we are living.

Truly useful digital channels will emerge from a judicious combination of experimentation, innovation, data communications standards, and enlightened policy making. The standards for Integrated Services Digital Networks (ISDN) are currently being developed to provide a basis whereby these digital channels can be accessed in a common manner worldwide. The access can be used for any type of information, whether it is voice, text, data or image. Experimental models and prototypes for ISDNs are being constructed in several countries.

This brings me to the standardization process and the international issues and challenges which you have asked me to discuss. Basically, there are two very key international organizations involved, namely, the International Telecommunication Union (ITU) and the International Organization for Standardization (ISO); and we should not forget the International Electrotechnical Commission (IEC) which also has an important role to play. Let me focus for a moment on the ISO/ITU relationship or even more specifically the relationship between ISO and the Comite Consultatif International Telegraphique et Telephonique (CCITT) for this is a very vital one. The CCITT, of course, brings together for the most part the telecommunications providers and the ISO brings together information technology users (both public and private sector) and producers.

Up to a few years ago, there was little dialogue between these two vital international standardization bodies, but now there is more, and I am happy to report the interchange is flourishing. Such interchange has already benefited the development of international standardization because both ISO and CCITT have adopted as standards the same OSI Reference Model and other OSI standards. In the interest of all of us, this type of cooperative effort must continue and increase in scope in the future.

It is always easy to criticize the standardization process because it involves too many people and takes too long.

To be fair, however, we must appreciate what the standards process in ISO is all about. ISO has already produced many, many international information industry standards covering areas such as telecommunications, codes and character sets, programming languages, media, user applications, user interfaces, etc. ISO brings together government, users, manufacturers, and network providers nationally and internationally to hammer out the standards that are going to be of the most use to the largest number of people. Sometimes the process is slow and cumbersome, but at least it is democratic and fair because it is one individual, one vote at the national committee level and one country, one vote at the international level. Nobody can dominate that process, but we all have to be involved with it and contribute to it. Today, whatever happens in regard to data communications standards will be affected by what is currently going on in ISO, the CCITT, and also the European Computer Manufacturers Association (ECMA). The manufacturers involved are working along with government, users, telecommunications providers, and others to develop new standards in highly important areas such as open systems interconnection (OSI), local area networks (LANs), and ISDN. Nobody knows yet what all of the final standards will be, and I am sure that in contributing ideas some will be accepted and others will not, but all will be considered.

Having mentioned open systems interconnection, let me just say a few words about it because it is very relevant to progress on ISDNs and international standards in general. OSI is the international standards project, started by ISO in 1977, whose aim is to provide communication protocol standards for interconnecting systems of different communications architectures. OSI standards are needed by users and manufacturers to provide communications capabilities among networks of different architectures. Accordingly, the manufacturers are very much involved with the OSI standardization process in ISO and CCITT. ISO and CCITT standards for the 7-layer OSI reference model already exists as well as initial standards for layers 4 (transport) and 5 (session), with standards such as X.25 already applicable to layers 1, 2 and 3 (physical, data link, and network).

In regard to LANs, ECMA standards encompassing token ring, token bus, and CSMA/CD already exist and are on their way to acceptance by ISO.

From what I have said, you may be getting the impression that already a lot of different architectures are arising. The fact is that they are. The reason is that users and manufacturers often make early and useful implementations of new and advanced technologies before standardization has had time to take place. This is not bad, because often the most useful standards turn out to be those that document successful and proven user experience.

A fact of life, therefore, is that there exists today a variety of data communications network architectures provided by different manufacturers which users will want to continue to use because they are particularly suited to their needs. This must be taken into account in the OSI standardization process because, if it is not, then it will not be possible for users to make full use out of ISDNs and their economic benefits to both users and network providers will be limited. ISDNs that truly meet user needs will profit not only the users but also the network providers and the equipment and services suppliers. This is the major challenge being faced today.

But now let us focus on ISDNs and their standardization requirements. In addition to the high degree of cooperation needed, there will have to be a very careful allocation of the work to be done between the CCITT and the ISO.

So far, most of what has been done on ISDN in the CCITT applies, as one might expect, to the first three layers of the OSI reference model, namely, those covering the physical interface and the user network signaling protocols. For example, the physical definition of the connector has been allocated to ISO and the electrical signaling properties of the interface with the network is with the CCITT.

One thing is clear at this stage and that is that digital interfaces are the wave of the future and we can expect that they will replace existing analog interfaces with few exceptions.

The current CCITT ISDN interface recommendations based on a 4-wire approach can handle a telephone and a terminal. The key question is can it handle all of the needs the users have today and which will continue to grow in an increasingly digital environment?

But there are other issues completely divorced from the standardization process itself that will affect using the digital channels and the ISDN standards needed. Examples of these issues are regulatory decisions, the degree to which users can define needs, and also, let us face it, political decisions which based on past experience in areas such as television have tended to split the world into regions.

At all costs, we must avoid country-by-country and even region-by-region variances in implementation of the ISDN standards, otherwise there will be needless differences, expenses, and problems for users. The need is for truly international data communications standards developed by the qualified international standards bodies. The regulatory decisions will decide where the boundaries are to be between the digital equipment and services to be provided by the telecommunications network suppliers and those to be provided by others. Standards work will be facilitated where this boundary is drawn and defined as clearly and succinctly as possible. Also, if the regulatory decision is in favor of competition in equipment and services then, based on experience to date, the standards community can expect to have to deal with a wider range of standards requirements due to the proliferation of such equipment and services. International agreement is needed, therefore, on a minimum set of data communications standards that permit worldwide compatibility and allow, for example, the user the option of attaching his equipment at each of the ISDN interface reference points. Also, ISDN standards should be defined in a way that does not preclude the separation of competitive functions from the basic telecommunications services within services offered via ISDN.

A major factor in the effectiveness of the standardization process in the emerging digital environment will be the degree to which the users are able to state and define needs and have them met by telecommunications network providers and the suppliers of equipment and services.

The commercial success of any new services or equipment depends primarily on the provision of tangible economic benefit to the end user who will be subscribing to individual services offered through digital facilities. Thus, the functions, interfaces, and network performance, just to mention a few parameters, must meet the users' objectives. It is essential that users' requirements be documented across a broad range of business and industry sectors. These requirements also must be communicated in a manner which ensures their consideration in the standards development process. The process of achieving this objective is complex and a challenge for all of us.

To ensure that data communications standards will be beneficial to the many user sectors, dialogue must be established and maintained between individual users, user organizations, industry associations, and network providers. Success depends upon users taking the initiative to communicate their needs to government policy makers.

One of the ways for you to be involved is to be in touch with your national standards body to find out how it is interfacing with the international standards work on ISDN. The national standards bodies have the capabilities to bring together not just the technical experts that are needed from the network providers and the information industry manufacturers but also your representatives who are the only ones who can ever really understand your requirements and express them properly.

Those responsible for planning the country's economic growth must realize that the growth of the information industry is an important factor. For example, competition in the U.S.A., which has been increased by the economic incentives resulting from deregulation, has broadened the participation in ISDN standards development. While a competitive telecommunication policy may not exist in your country, it would seem beneficial to open national CCITT committees to all interested parties to ensure that the broadest range of requirements are reflected in the country positions presented to CCITT. Effective means must be provided to allow all affected interests to be involved in determining the proper standards, both at the national and international levels.

A key objective in pursuing standards is to promote a minimum set of standards established on a worldwide basis defining access to digital networks with the necessary functional/performance characteristics. This will minimize development efforts and costs for both customer and carrier products, maximize freedom of action in development and manufacturing, and meet the requirement of larger market potential for the national industries.

Product and system compatibilities between countries, as well as within a given country, play an essential role in overall cost minimization. In order to achieve this goal, users and manufacturers, for example, should participate in the specification of national ISDNs.

But, let's be optimistic and assume that all of this will be done. That user needs will be sufficiently defined and properly integrated into the data communications standards for a digital world. Then the question is can the international standards mechanism handle the job?

My answer is yes, provided we use it and don't abuse it. The workload going to be imposed on the ISO, the CCITT, and the IEC is going to be enormous even assuming a proper and appropriate distribution of that workload and the closest cooperation among the three bodies.

As it exists today, cooperation of this kind drains a lot of the very scarce expertise that is available. In addition to working in their respective fields, the technical experts involved have already to spend a great deal of their time, not on producing standards, but on liaison to be sure conflicts, overlapping activities, and duplication of efforts are avoided.

If, for political and other reasons, this picture is compounded by regional standardization efforts, then the squandering of resources goes up exponentially because the experts now have to liaise not only with the international bodies but also with the regional bodies and often, in turn, their national bodies.

If the potential of new digital channels is going to meet the needs of the users, then it is essential that the standardization work which requires significant amounts of time and resources be done once, be done right, and be done internationally.

There is no doubt that the environment in which we operate will change dramatically and that digital channels are going to be of major significance in all fields of human endeavor--finance, government, education, manufacturing, employment, media, entertainment, transportation, business and personal communications, health care, working at home, law, insurance, and information services of all kinds affecting national and individual prosperity and well-being. That is why government policy makers should determine if the regulatory environment in place today will provide the proper stimulus for the economic benefits that digital technology can provide in the future.

In effect, the emerging digital environment is going to affect our future and quality of life as nations and individuals in ways that we cannot even envisage at this stage. Therefore, the foundations on which networks like ISDN are built must be capable of withstanding time and structure that we cannot fully dimension at this stage. This is a task that requires the collective involvement of us all, the professional standardizers, network providers, manufacturers, and users. Without it, the proper foundations will never be laid.

As we continue towards a "Digital World," the international issues and challenges we face are complex and change will not come easy; but the outlook is bright, the potential for achievement is great, and through the dedication of many, particularly groups like the PTC, we will achieve success.

THE IMPACT OF CHANGING USER REQUIREMENTS ON INTEGRATED DIGITAL NETWORK SYSTEMS

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1. ABSTRACT

This paper discusses changing user trends and their effect on the current telecommunications network as it is changing to an Integrated Digital Network. To obtain ubiquitous combined voice-data access and economically exploit it within any reasonable time frame, this paper concludes that Data Above Voice techniques may also be needed to meet the changing user requirements that are forecasted, and that both circuit and packet switching techniques with a single optimized access may result.

2. INTRODUCTION

In the U.S., the last ten years has seen a dramatic shift of people from manufacturing functions to Service functions and Service industries. The next ten years this will level off at about 75% of the workforce. The major thrust will be the automation of the Service function, with communications being a key "automating" element. Another word for this is 'newservices' - telebanking, teleshopping.

Local communities of interest, business establishments would move towards the automation of the office with the "office controller" as the key communicating element in terms of voice and data demanding network bandwidths in the range of gigabits per second.

Intercommunity communications will be more individual oriented and the Personal Computer will emerge as the most important new terminal. This will place a large demand, in [illegible] in the range of 2.4 to 9.6 Kilobit/sec data with digitized voice on the network to force the exploiting of the ubiquity of Integrated Digital Network. New uses will constantly be found to generate more usage once packet switches are embedded in the network. Services such as "common banking tellers" for multiple banks could expand.

All this, however, depends on the current non-loaded loop becoming more versatile in terms of simultaneous data and voice with the data above the voice band at 2.4 to 9.6 bits per second.

Intelligent nodes would be created to handle the access lines such that traffic could be routed more efficiently to different types of networks - packet or circuit switched. Bandwidth could also be provisioned on demand.

To enable all this to occur as the current telecommunications network is changing would require transition techniques of routing the simultaneous voice and data traffic around the existing analog switching base. Techniques such as Digital Cross Connect, with the deployment of integrated optical fiber, is foreseen.

This paper emphasizes that the end-user requirements that may shape or impact Integrated Digital Network Systems significantly is the simultaneous 2.4 to 9.6 Kilobit per second need coupled with single access on an optimum basis to both circuit and packet switched networks.

In conclusion, this paper foresees that the fully ubiquitous ISDN will evolve from changing user requirements and discusses how this will impact network planners, equipment supplier, and telecommunications carriers.

3. THE SERVICE FUNCTIONS AND THE NETWORKS

The curious thing is that today we do know we are in the midst of an information revolution, but our awareness is not that much help since its dimensions cross over territories widely separated organizationally and culturally. One major context of this revolution is the increase in the intensity of sharing of information through communications and the ability of the knowledge worker to utilize information effectively with the aid of intelligent tools.

The second major context with which we have largely identified in recent years is the post industrial society. The post industrial society has many dimensions. One is that it will become increasingly a

Service oriented society. In the U.S. today, about 70% of the labor force are engaged in services, only 17% are factory workers. By about year 2000, 75% of the work force will be employed in Services Industries and only 10% will be factory workers. If you think this is extraordinarily low; consider that today only 4% of the work force are farmers and they are producing food for the U.S. and the rest of the world. Overall the U.S. is undergoing shifts in employment similar to those that have been taking place regularly since the industrial revolution. The expansion of services and shrinkage of some older occupations are now showing signs of natural growth and aging process.

Every society has large components of services. In an industrial society, the services are auxiliary to product, transportation, utilities, finance and other operational areas. In a post industrial society, they are human services, such as education, health, social, professional, analytical, banking, data processing, etc. All of these are part of new ways of creating the networks that tie people and and Service functions together.

The third major context involves the telecommunications and computing technology revolution, which we have been experiencing over the last two decades.

There are three aspects of this revolution. One is digital switching - crucial to networks. Networks tie people together. There are several kinds of networks, all tied together by switched communications. Thus digital switching has become a dimension of a different way of thinking. Stored programmed control and analog switching has been the backbone and is being modernized to digital rapidly.

The second aspect (an important one), which is the core of the technology revolution, is the idea of miniaturization. Large Scale and Very Large Scale Integration (LSI, VLSI) and packaging of electronics enable us to have 64k, 256k and even 1000k chips on the size of a thumbnail. This allows the power of a large mainframe computer to shrink to a desk-top computer, with higher reliability and lower costs.

The third aspect is software. Software has played a dominant role in switching over the last two decades. The use of computing power (intelligence), we witnessed in our switching systems, will find cost effective applications in a wider range of communication network products.

One major effect telecommunications has on us is the building networks of human communication and reknitting them. We must use it to exploit the opportunities for the progress it offers.

Question is not, will there be opportunities? - but rather how many? We need to address them quickly to support user needs.

Another important aspect of the telecommunications revolution is that it is becoming a significant driving force in shaping the human community. The basis of human community is communications, which will be addressed through integrated information networks for single marketplace - an information marketplace, whic is divided into communities of interest, no differentiated by geography or classification.

4. THE USER NEEDS AND THE TECHNOLOGY

The shift that has been taking place in the American industry, since the last two decades, is the result of changing markets, technology advances, and automation both in factories and offices. This does not imply the end of smokestack industries or reduction in the quantity of goods produced, but merely the computer integrated manufacturing and automation of manufacturing processes.

Inefficiencies in both the manufacturing and service industries will be countered through the factory and office automation and increased usage of communications (voice and data). Communication devices, personal computers, PBX, office controller, Local Area Networks and digital transport facilities become agents to facilitate the information movement.

The communications services will be considered a backbone to getting information to the right people, in the right format, at the right time. Speed, accuracy, quality, reliability and competitive cost are some of the key attributes.

Application of technology to provision and delivery of information is fast becoming a survival issue - a necessity in banking, factories and Information Services industry.

The increased information access, flow, networking and management is essential both for productivity and profitability. The networking and automation of systems is considered no longer merely to support operations -- they are operations! The convergence of communications and computing is accelerating demand for Integrated Information Networks and Services.

The expanding services in voice, data, and imaging for all user segments (residential, small and large business) are emerging at a phenomenal growth rate, such as telemarketing, teleshopping, telebanking, teletraining, telediagnosis and teledelivery, home entertainment, teleconferencing and so on. The services domain collectively will grow 11% annually through the 1990's, from $242B to $572B in the U.S.

The user requirements segmented, by broad categories (i.e., residential, small business, medium/large business), are different and changing. The key requirements foreseen are: Integrated voice/data over a single pair of wire, cost sensitive usage (time and bandwidth), access to a host, to Local Area Networks (LANs) and to Value Added

Networks; standard protocols and interactive processing for a variety of home and business service offerings. The continuing technology evolution makes it possible to satisfy the changing user needs.

However, people also must be willing to use new technologies - attitudes do not change at the same rate as technology. Therefore, we must design our system, facilities, equipment, which accommodate the user needs, attitudes, and cost competitiveness. A rational approach would be evolutionary in nature; i.e., first a desk-top PC, next, Interface of PC to PC, PC to LAN, PC to networks and then internetworking of LANs via public networks.

This evolution will lead us through the end of the 80's, and in the early 90's, we shall see user friendly communication terminals interface with local area networks and wide area networks through ubiquitous access techniques.

Further development in the telecommunications (digital technology and networking) will move us towards a world of integrated services digital network (ISDN) - a vision nothing less than a planet-wide communications system for provision of voice, data, imaging and message services.

5. IMPLICATIONS

With communication services as the key ingredient for increasing human productivity, both in offices and in factories, we can foresee some trends impacting the networks, and encouraging integration of voice, data and imaging. Growth in communications terminals, particularly the growth and acceptance of personal computing and other network access devices, is expanding the volume and the data usage. This will result in significant impact on local and remote networking.

The implications are numerous to the restructuring and design of networks, driven by the market needs; such as:

- o Internetworking of voice and data networks - using circuit and packet switching.
- o Cost effective ubiquitous access to the network.
- o Variable bandwidth; e.g., 1.2 kb/s to 64 kb/s to 1.5 mb/sec.
- o Standard protocols and interfaces for multi-vendor equipment and internetworking.
- o User control of integrated services and network operations.
- o Audio-visible communication terminals.

Competitive cost, reliability, end to connectivity, higher bandwidth offered over the public networks are the keys to the success for information services offerings.

Intercommunity communications will be more individual oriented and personal computers will emerge as the most important new communications terminal. Initial cost considerations and adequacy of data speeds in the range of 2.4 kb/s to 9.6 kb/s, together with the digitized voice in the network, will allow us to exploit the ubiquity of integrated digital network. Local communities of interest, business establishments (large and small) would move towards office automation, with PBX as office controller and LANs existing side by side in terms of voice and data movement. These LANs will be interconnected with other local or remote LANs or hosts through public or private packet switches.

The employment of digital technology will facilitate loop becoming versatile for carriage of voice and data and provide end to end digital connectivity. Bandwidth would need to be provisioned on demand, cost effectively, depending upon marketing strategies and needs.

6. IMPACT ON THE NETWORKS

During the recent years, we have experienced a rapid evolution towards the use of digital techniques for voice and data services. Service dedicated networks have been implemented, starting a trend towards integration of transmission, signalling and switching technique. The voice Integrated Digital Network (IDN) is based on transmission and circuit switching of 64 kb/sec pulse code modulation (PCM) voice channels. Data communication over the public network has evolved from analog based and switched connection, through the implementation of point to point digital networks up to the establishment of data IDN's based either on circuit or packet switching techniques. Diverse and changing requirements for service will be a prime force for shaping the evolving digital network. The services in turn would be market driven. This will force the evolution to ISDN so that a small family of customer network interface can be used to a wide variety of services.

In general, ISDN's are conceived as the networks which will (1) evolve from the voice IDN; (2) provide end to digital connectivity to support a wide range of services, not only for voice and data, but also video application; (3) use a variety of communication nodes, including both circuit and packet switching. The key element of service integration in the ISDN is the provision of an integrated local access to the planned multi-service communication capabilities. Access protocols, service features and performance, as perceived by the user through a set of standard user network interfaces, are the basic ingredients of the ISDN.

7. BUILDING BLOCKS

ISDN has been termed as a common element of an international network evolution strategy to support an expanding array of information services, provide solution to ever changing business and individual communication user needs.

We see the following key building blocks essential to reach the ISDN goal. They are:

- o Network intelligence with powerful processing, storage and software features.
- o Integrated access to information resources and services.
- o End to end digital transport capability with flexible signalling capabilities.
- o Enhanced network management and administration capabilities.
- o A set of internationally accepted standards to allow flexibility and exploit the growth and continuing evolution.

These building blocks become a planning direction towards the evolution of the digital networks.

Network Intelligence

As outlined above, building ISDN functionalities into the digital network is well underway. One of the important building blocks for ISDN is providing capacity and intelligence to the digital switching machine. Northern Telecom intends to exploit the architectual flexibility of our DMS-10 and DMS-100/200 systems. Meeting evolving user needs has created a strong and rich feature base on our digital products. Flexiblity is provided in the system architecture by placing the total machine operation under distributed software control between powerful central processing unit and microprocessor based peripherals. The new features have continually been added and put into service to demonstrate the flexible architecture of the DMS machine. The DMS family will be the primary vehicle for ISDN implementation. To date, over 1500 DMS-100/200 and DMS-10 systems have been put into service world wide.

Access Arrangements for Services

By means of a single access link, the user may access a range of network and vendor services simultaneously. The market development activities involve using defacto standards and existing installed outside plant.

Data Evolution

Ubiquitous service in the evolving business world is key and must include DATA and the ability of the emerging network to provide these capabilities cost effectively.

From an operating point of view, the essence of the ISDN concept is the access network integrating voice and data services over physical facilities. From a network planner's viewpoint, the essence turns to the provision of both circuit and packet switched facilities. A range of data speeds and services will be demanded. We see the need for integrated voice and data (9.6 kb/sec or lower) for services, allowing simultaneous voice and data communication. The applications covered in this area would include business services, such as alarms, telemetry, text, credit card verification, E-mail, etc. The higher speeds at 64 kb/sec will be provided through circuit switched data for most 'data transfer' services, such as facsimile, PC to PC communication, point to point, etc.

The evolution of data and integrated access takes on a number of dimensions. They involve 'data above voice band', packet switching and circuit switching. Clearly, the ISDN implementation would be incremental and some transition techniques would be employed to provide cost effective services, until the full implementation of ISDN evolves.

Circuit Switched Data

Northern Telecom products have been moving down the evolutionary path for several years now. In order to enhance loop plant capabilities, there are two primary paths: higher speed capability 64 kb/sec and simultaneous voice and data. A circuit switched direct digital system (CSDDS) arrangement was used with our DMS-100 system in a technical trial in 1981. This arrangement exploited the fully digital data transparent qualities of the DMS machine. For long loop, Northern has developed a digital line card (using TCM technology), which provides end to end digital access over an unconditioned single twisted pair. This service is called DATAPATH, and is available and in service now. The DATAPATH arrangement supports duplex data rates up to 64 kb/sec synchronous and 19.2 kb/sec asynchronous. In addition to the customer data stream, a separate 8 kb/sec control channel is implemented. This arrangement is of the same service structural form, as the emerging ISDN 2B+D. DATAPATH also provides for routing on the switching systems trunk side over digital facilities or over analog facilities using pooled modem capability in an IBM 3278 emulation mode.

In parallel with this activity, simultaneous voice and data access arrangements are being evolved. Northern Telecom's first use of simultaneous voice and data access arrangement was with SL-1 digital PBX and SL-1 subscriber set in 1978. The SL-1 arrangement uses two pairs. DMS-100 business set, available now, has taken this approach over a single pair subscriber loop operation.

Integrated digital data can be carried economically over the voice band switched access for installed base of terminals, including V.24/ASCII, SNA and PC.

For short loop environment, our 'Data Unit' supports asynchronous 19.2 kb/sec up to 4 kft using 4 wire. This arrangement is particularly useful in offices/buildings.

Access to Packet Switching

It is generally accepted that ISDN should be based on and evolve from the 64 kb/sec circuit switched voice IDN, including digital subscriber loop facilities. Circuit switching is a cost effective technique to handle data application characterized by high terminal activity during the call (bulk data). Packet switching is advantageous for 'Interactive' (low activity during the virtual call) data applications, such as start/stop, terminal to computer applications.

Northern has built a solid base of experience in packet switching through the SL-10 packet switching system, first put into service in 1976. In 1983, an access device called SL-10 RAPID was introduced to provide protocol conversion and concentration as an integral part of the network. Some 157 SL-10 systems are now deployed in 15 packet switching networks world wide.

To force the ubiquity of network, the need for data above voice band over a single pair of wire, is well recognized. Data will be channeled to SL-10 for packetization. For analog application, data will be channeled by RAPID before sending off to SL-10 packet switch, using a DS-1 multiplexed line. Data units are available on DMS for CSDDS for speeds up to 64 kb/sec. Further evolution will include LAN units (trunk) for interfacing with CPE LAN type service offerings. Thus we intend to provide cost effective fully digital circuit switched access to packet networks via packet-assembler - disassembler (PAD), using X.25 protocol. Market trials can be conducted to demonstrate switched area-wide 64 kb/sec transport, where Integrated Digital Network is an installed reality.

Prior to implementing the commercial ISDN 144 kb/sec 2B+D arrangement, it is anticipated that further technical trials would be run using advanced hardware and software, during 1985.

The PBX to network access will utilize the 23B+D as the primary access, using T-carrier transport. Northern Telecom is continuing to work with national and international standard forums (ECSA, CCITT, EIA, etc.) to ensure compatibility.

End to End Digital Connectivity

This implies that signals enter the network and transported across it in a digital format. They are delivered in this form to distant user or to another connecting ISDN.

The common channel signalling (CCS) is central control to central control communications network employing packet switching techniques to transfer signalling messages among the switches. This is another key building block of ISDN. After three years of operating experience with CCITT #6 in the Montreal DMS-300 Gateway switch in 1981, CCIS is now installed and in operation in Ocala, Florida. DMS-100 family products common channel signalling is progressing towards the CCS-7 based on ECSA and CCITT #7 standards. System architecture for our DMS-100 digital systems has been proven to be robust to incorporate the CCS #7 during 1985.

Network Administration and Control

It is essential to provide customers the necessary control to allocate dynamically the capacity of the ISDN access link to different services and to select the network services derived as a real time via customer to network signalling. Northern Telecom has a range of products (LRS, DFMS, NAMS) to provide the necessary maintenance and administration feature under the customer control. In Northern Telecom, heavy emphasis is being placed for developing Network Operational Systems (NOS) to support the OAM functions efficiently and cost effectively. In 1985, we will begin offering NOS products, such as 'customer network management' for DMS machines and special services digital network for digital cross-connects. These network control products will be evolving and tied together through the use of common protocols based on CCITT standards.

Standards

Another key element of service integration for ISDN is the provision of a limited set of standard user network interfaces. We believe and support the position that CCITT ISDN standards, when firmed up and agreed to, should and will form a basis to assure compatible interfaces to network and terminals for world wide connectability. It is also essential that we agree to standards based on OSI layers protocols if we are to achieve commonality and connectivity to networks, multi-vendor equipment and applications through a set of common protocols at all levels of network operations.

8. CONCLUSION

This paper has addressed the impact of the changing user needs for services on the Integrated Digital Networks. The fundamental building blocks are in place. The work is continuing to evolve from IDN to ISDN. The fully digital network intelligent nodes of Northern Telecom's DMS-10 family, DMS-100 family, SL-1 family and packet switching SL-10 have been evolving with the network to support multi-service applications and provision of end to end digital connectivity. These efforts attempt to exploit harmoniously the current service dedicated network facilities and are focused in local access integration through communication technologies.

How will the market demand evolve for these sophisticated services? What is the optimum levels of integration of facilities and switching functions? It is not easy to forecast. The only viable route is to explore the market and follow its needs. We have actively solicited partners to explore and do market trials for developing winning telecommunication services for our Telco customers.

We have taken the approach to integrate our research development effort with market trial approach to the implementation of ISDN in conjunction with the users as well as the service and network providers.

ISDN's will be a driving force in bringing benefits of information age to business and industrial users. The standards and flexibility will allow ISDN public network providers to offer ISDN services in an economically, efficient fashion.

"SMART BUILDINGS FOR INTELLIGENT PEOPLE"

By

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ABSTRACT

The emergence of the "smart design" and "intelligent building" will direct building developments in the 80s. Intelligent buildings are those structures which include teleconferencing, telecommunications, local area networks, energy management, and other new information technologies. In an increasing number of cases, these buildings are designed by CAD systems (computer-aided design).

Today, architects are challenged to design buildings that incorporate the new office automation technologies to make people more comfortable, better connected and, ultimately, more productive. Simply introjecting smart office equipment into an organization, however, often results in barely controlled chaos. This is clearly visible in many offices and building complexes, where, for example, a continual re-arrangement of equipment, desks, partitions, and people exists. Because each workplace now tends to have a complicated combination of terminals, telephones, and cables, more than one person and one department is involved in making decisions about "what and who goes where". Organizations will come to value design features simplifying the automation of offices and buildings. These design changes will run the gamut from good cable management to floor layout.

Some of the many technological and social factors affecting the approach taken to design intelligent buildings include the following:

- Most of the technology having the greatest impact on office design over the next ten years already exists, and is in use by leading-edge organizations. How these technologies will be integrated with existing office technology, and how rapidly the office worker will assimilate these systems into daily work life will be major issues.

- Information technology is not easy to assimilate into office buildings.

- Specifications for new intelligent buildings is more stringent than is generally assumed. Office buildings are presently described in terms of the way they are constructed. Rarely are they described in terms of the way they are used. Data on how buildings can be designed incorporating information technology is critical to planning.

- Currently, office automation manufacturers have addressed only micro-issues in the work environment. The innovators will provide a "systems" approach.

In designing intelligent buildings, it is necessary to understand new technologies as well as review the management styles and communications infrastructure of those organizations using the intelligent building. See Figure One for features of an intelligent building.

In the past, decisions in the field of data processing have been monopolized by specialists. This trend is fading rapidly because more and more user departments are making the decision to purchase and control their own systems. Moreover, now that the interface between telecommunications and data processing has been made technically-feasible and people understand the connection, the complexity of decision-making about information technology within the organization has increased, rather than decreased. There is controversy about who will manage the new and converging systems, and whether it should be carried out in-house or by systems integrators. This type of confusion is analogous to problems in building design and facilities management. No one profession can take sole charge. No decision is so simple that it fails to have implications in at least one other field.

Information technology, especially office automation, is likely to change the way in which organizations make decisions about the allocation and type of space needed. Studies such as The Orbit Study, carried out by DEGW in England, show that a great deal of coordination is required between servicing departments having maintenance responsibilities, and those operational departments which procure and use the equipment. The difficulties experienced in installing equipment and distributing terminals illustrate just how interdependent buildings and work operations have become. Consequently, it is often the case that both building managers and computer systems personnel become involved in decisions about future building requirements.

The Orbit Study indicates that more discriminating clients are emerging. They will no longer judge buildings soley on traditional criteria (location, rents, finishes, etc.), but will, on the basis of past experience, include a building's capacity to take information technology into account throughout the entire building system. At present, the needs of information technology do not appear to be adequately understood by either the suppliers or consumers of office space. Good building performance criteria are sorely needed, and these studies should be a tested.

Many organizations just "bolt on" new technologies, telephones, local area networks, teleconferencing equipment, and satellite receiving dishes. Intelligent buildings, however, require intelligent designs that integrate new technologies into the design of the organization. This will create the conditions allowing human intelligence to flourish in the workplace.

While information technology makes intelligent buildings possible, the driving forces behind them are:

- Regulatory Change - The telecommunications industry's new post-divestiture competitive environment, and the rapid advances in information technology are shaping the emergence of the shared tenant telecommunications market. The Bell System no longer supplies all the needs of businesses. While the seven Bell operating companies still provide local telephone service and sell equipment, essential communications functions provided prior to divestiture may no longer be available. To obtain and operate a competitive multi-tenant information system, the building owner may have no choice but to be in the phone service business if he or she wants to keep tenants and attract new ones.

- Economic Advantages - The increased efficiency of office automation and energy management provides important economic advantages in lowering energy, labor and operating costs.

- Maintaining Technological Edge - The only way a small company or branch office of a Fortune 500 company can afford current and future generations of advanced telecommunications equipment and services is through sharing. Equipment providing office automation and energy management services is too costly for a tenant occupying less than 100,000 square feet to afford, let alone the technical staff to support it. A multi-tenant intelligent building provides these services to such firms on an affordable basis.

- Competitive Edge - In a recent CIC survey, 78% of those developers contacted stated plans to build intelligent buildings. These would include a mixture of telephones, energy management, data processing, tele/conferencing, and secretarial services. It is estimated that 60 totally intelligent buildings presently exist in the United States. As information technologies evolve into a staple item, most commercial developers will provide tenants with such systems and services. Buildings will then need these systems to attract new tenants. A building without such enhancements will be at a serious competitive disadvantage.

- Suitable Office Environment - Concern is growing in the business community that the office environment be suitable for both in-house and work-at-home telecommuting employees. As competition for staff knowledgeable of the new office technology increases (such staff is already in short supply in many areas), the quality of the overall work environment will be critical to employees. In an increasing number of cases, employees are examining the type of information "power tools" available to them prior to employment, and tenants must be able to attract new employees.

- Investment Opportunities - Intelligent buildings used on a multi-tenant shared services basis provide profits for owners. It is estimated that revenues for building owners having set up a well planned and operated building information system can run as high as $25 per square foot per year. With this revenue, owners can afford to reduce rents for attracting new tenants. However, due to the relative inexperience of this industry, caution is urged.

- Building Management - Pressure from building owners, who constantly stress the need to reduce costs and manage building facilities (air, space, energy) more effectively, will force the issue of incorporating new information technology into the building system as a competitive edge.

- New Jobs - A recent study shows that by the end of this century, eight million jobs will be created in computer-aided design and manufacturing, and one million more will be created in software writing. If industry in this country does not adopt new technology - with the intelligent building as the vehicle - there will be a loss of jobs and an inability to compete in international markets. Intelligent buildings therefore have farther reaching consequences than initially apparent.

In designing intelligent buildings, it is necessary to understand the new technologies as well as review the management styles and communications infrastructure of the organizations using them. Intelligent buildings will require intelligent designs integrating new technologies into the design of the organization. This is due to the fact that information technology, especially office automation, is likely to change the way in which organizations make decisions on the allocation and types of spaces needed.

Intelligent buildings are geared, for the most part, toward multi-tenant services, but not all organizations benefit equally from the multi-tenant approach. Large companies, which can afford their own computer and telecommunications equipment, are reluctant to get locked into a building system that duplicates what they already have, or, in some cases, appears to be less reliable than their own equipment.

Medium-sized and smaller companies, however, benefit from an in-house network provided by a building developer. Smaller companies, who often cannot justify the cost of owning their own equipment, can lease high-tech services just as they do office furniture. The actual cost of services will be figured by the choice of menus and length of time the user is on the system. Tenants have specific needs and issues, which are important to understand in designing an intelligent building which will service a wide variety of tenants. Following are problems developers of shared-tenant intelligent buildings face:

- More Demanding Tenants - Saunas, jogging tracks
- Rapidly Changing Needs - "here today, out of business tomorrow"
- Custom Environments and "Designer" Furniture - "Will the next tenant want pink walls?
- Cost Conscious Issues - "Has anyone made any money at this?"
- Unproven Tenant Demand

The real demand for intelligent buildings may well be with the new and/or smaller tenant. There is a rapid increase in the number of small, fast-moving, innovative entreprenuerial firms. These organizations are expected to adapt to new information technology more rapidly than older, established organizations, and be especially demanding of information technology that will meet their needs.

Even in larger organizations, both de-centralized administration and production in large organizations contribute to the above emerging pattern of smaller working units. Large organizations increasingly delegate decision-making to smaller and more autonomous business units. This is due to improvements in all forms of communication such as teleconferencing, which increase the available options of organizations to either centralize or de-centralize their operations. For example, greater accessibility to information and communications via computer networking is changing traditional functional, and departmental (and thus space-geography-time) boundaries. In the past, office workers needed to be close together in large office buildings. Now, they can be located thousands of miles apart, across many time zones, and work shifts (day-night), and still "feel close" to one another.

A result of these changes is the concern that the office environment will be suitable for both the in-house and work-at-home telecommuting employees. These new environments are not fixed offices but adaptable work areas that are movable, programmable, and allow for personal expression. Tenant concerns over all this technology show a need for:

- Shared but Secure Technologies - "Don't want anybody listening in to my telephone calls."
- Modular/Expandable Proven Systems - "Can it grow with me?"
- "User-Friendly" Training and Support - "Where did the vendor go?"
- Reliable and Accountable Systems - "Who is really responsible for billing?"

Intelligent buildings house intelligent offices, staffed by intelligent workers. The difference between a traditional building and intelligent building and is, initially, the information technology that it incorporates into its very structure, including computer-aided design for building exteriors as well as for interiors. This difference leads to differentiation of tasks performed by the tenants of the building, and thus of the tenants themselves. New management strategies must be developed to cope with the influx of information technology into the intelligent office, and those people who work with this new technology.

There is no question that intelligent buildings are coming. Developers, facility managers, vendors, and tenants are wanting the capability of the technology for shared services which translates into lower costs to the tenants and higher occupancy for the developer. Over the long-run, buildings will be networked together offering even more advanced technology.

AUTHOR

Thomas B. Cross is Managing Director of Cross Information Company - a research and development company. He has authored over 50 articles on tele/conferencing, intelligent buildings, and information technology. He is co-author of *Teleconferencing: Linking People Together*, *Electronic Communications*, and the *Softside of Software*. He is writing a book on intelligent buildings, personal computer networking, and telecommuting for Dow Jones Irwin and teaches Trends In Information Technology in the graduate school at the University of Denver. CIC sponsors conferences on *Intelligent Buildings & Information Systems* and the annual *International Tele/conferencing Symposium* as well as reseach reports on intelligent buildings, CENTREX, Telecommunications Outlook, and The Orbit Study.

FIGURE ONE

Following is a list of features detailing the "intelligent building:"

INTELLIGENT BUILDING MANAGEMENT

- Online Administration and Financing
- Computer-Aided Design Space Management
- Online Facilities Management and Planning

INTELLIGENT COMMAND AND CONTROL

- Life Support and Comfort - Personal Comfort Environments
- Online Power Management
    - Uninterruptable Power Supply Systems
    - Power Generation
- Wire Management - Building & Local Area Networks
    - (BAN/LAN)
    - Power
    - Computer
    - Telephone
- Online Building Control
    - Remote Administration
    - Simulations
- Maintenance
    - Repair and Diagnostics
- Security
    - Access and Reporting
    - Protection
- Traffic
    - Flow
    - Accounting and Control

INFORMATION TECHNOLOGIES

- Shared-Tenant - Telecommunications
    - Video Tele/conferencing
    - Audio Bridging Services
    - Audio-Graphic Equipment
    - Sale, rent, lease of telephone station equipment and data communications systems
    - Sale, rent, lease of computer systems
    - Intercom-only and access to local calling service
    - Standard and advanced calling features
    - Installation of systems
    - Maintenance of systems
    - Moves and changes
    - Billing and Management reports
    - Special account codes
- Messaging
    - Telephone Answering
    - Electronic Text Messaging and Network Interface, Voice Mail
- Network Interface - Carrier and Bypass
    - Access to CATV networkings/programming
    - Access to external online databases
    - Remote Access Ports
    - Modem pooling
    - Packet Network Interface
- Paging
    - Speaker
    - Pocket Pager
    - Cellular Telephone
- Tenant/text - Building Directory & Information
- Online Concierge
- Archival Storage -
    - Online Storage
    - Vault Storage and Document Shredding
- Intelligent/Movable Programmable Offices
- Online - Word/Data/Info Processing
- OCR/Facsimile/Telex
- Tenant Support and Training
    - Computer-Aided
- Encryption/Systems Security

INTELLIGENT RESOURCES

- Conference and "War" Rooms
- Temporary Services
- Package, Courier, and Delivery Services
- Travel, Conference, Meeting Planning Services
- Day Care and Health/Recreational Gyms
- Print/Copier/Office Supplies/Services
- Interior Design Services
    - Computer-Aided Design
- Educational/Training Services

DDX - Its Operating Experience

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In 5 years of operational experience of the DDX (Digital Data Exchange) networks in Japan developed by Nippon Telegraph & Telephone Public Corporation (NTT), important usage trends such predominantly higher signaling rates terminals and strong preference to X.25 packet mode terminals are revealed. NTT's networks and service extension plans to evolve the DDX networks toward INS as basic transmission network for non-voice communication are also presented.

1. Introduction

Rapid progress in data communication technology development has resulted in the increased importance of communication links which interconnect multiple computers and various terminals.
The number of circuits to be used for data communication has been drastically increasing in Japan as shown in Fig. 1. At the same time, it becomes apparent that conventional analog type communication links, such as public switched telephone network and leased circuits, cannot meet the demands for more enhanced, more diversified data communication systems.

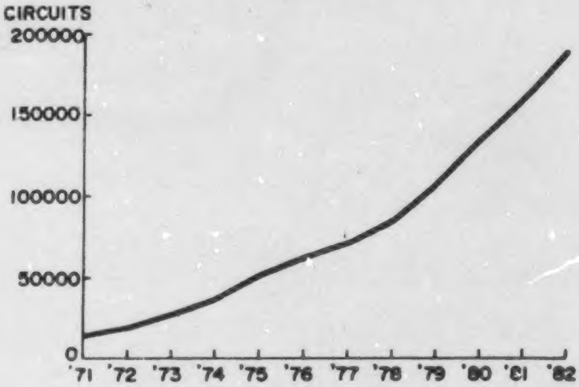


Fig. 1 GROWTH OF DATA COMMUNICATION CIRCUITS

Given this background, new digital transmission and digital exchange technology for data communication has been developed since the end of 1960s with close cooperation of CCITT Study Group VII activities. Since early stage of the studies for new digital data networks, NTT has put strong emphasis on the international standardization efforts.

There are a wide variety of characteristics of data communication traffic regarding length of message and volume. In order to provide an economical exchange network service for any type of data communication, two kinds of new public switched data networks have been put into use, circuit switched one and packet switched one.

In Japan, NTT began operation of a circuit switching service DDX-C in December 1979 and packet switching service DDX-P in July 1980, after more than a decade research and experiments. Fig. 2 illustrates the expansion steps of DDX networks.

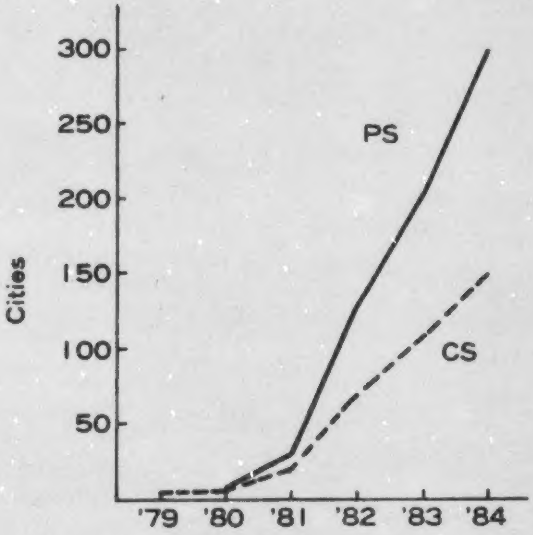


Fig. 2 GROWTH OF DDX SERVICE CITIES

2. Present Network Configuration and Service Features

In the circuit switching network, there is no storage or conversion of data signals. The main characteristics of this network are that there are no restrictions on data format and no transmission control procedures. Thus, it is suited to the transmission of relatively long and high density data used in data or digital facsimile communications.

In the packet switching network, on the other hand, data or messages sent from a calling terminal are stored in the network and then assembled into a block of constant length containing address, logical channel number, etc. Messages are transferred rapidly by repeating store-and-forward activities to a called terminal. It is suitable for relatively short message, low-density data communication. It is particularly outstanding in its quality of transmission and communication between terminals with different data signaling rates. Fig. 3 graphically illustrates optimum use of telephone, leased circuits, circuit switched and packet switched services.

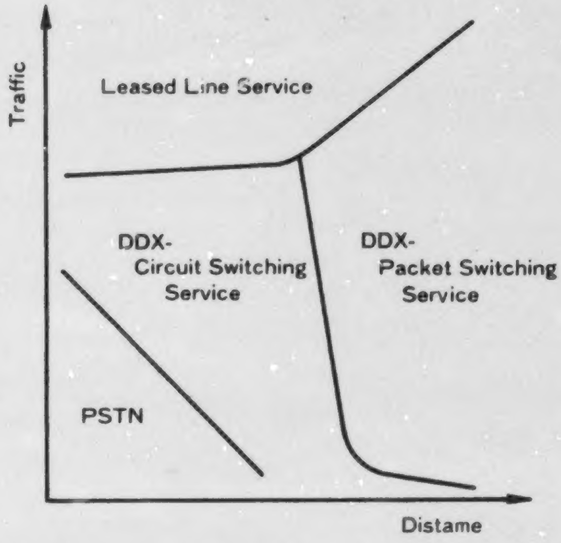
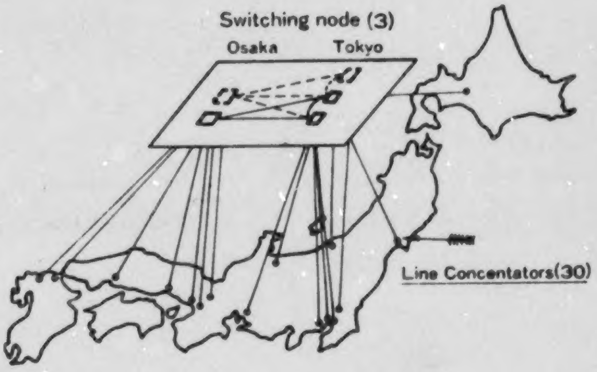


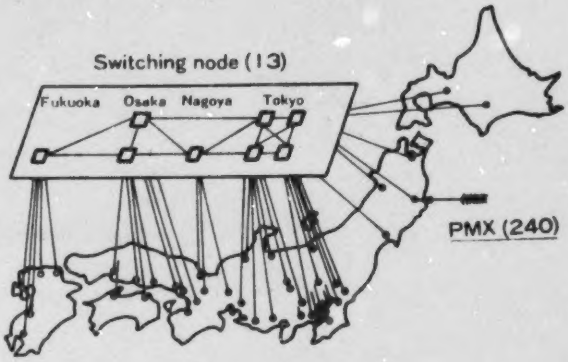
Fig. 3 CHARACTERISTICS OF SERVICES

DDX is offering a wide range of speed classes from 200 bps to 48K bps and variety of optional user facilities, as 'Closed user Group', 'Direct Call', 'Calling and Called Identification', 'Lump-sum Charging', 'Abbreviated Dialing' and 'Reverse Charging'. Moreover, DDX-P service offers protocols including X.25, X.28, HDLC, etc.

Both DDX-C and DDX-P started from star configuration with a switching office in Tokyo with four service area cities in the DDX-C case, and with seven cities in the DDX-P case. The present network configuration of DDX-C, as shown in Fig. 4, is dual node network with switching offices in Tokyo and Osaka for 107 service area cities. As a result of the network expansion and traffic growth, DDX-P has grown into a multi-node network with four switching offices in Tokyo, Osaka, Nagoya and Fukuoka for 206 service area cities.



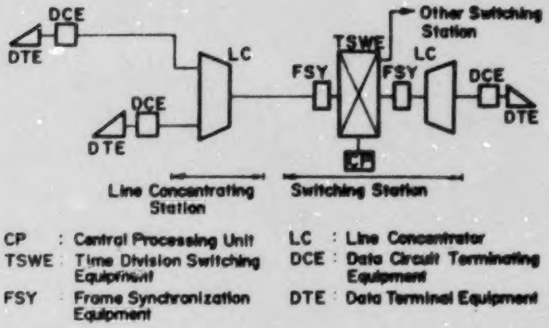
CS Network (1984)



PS Network (1984)

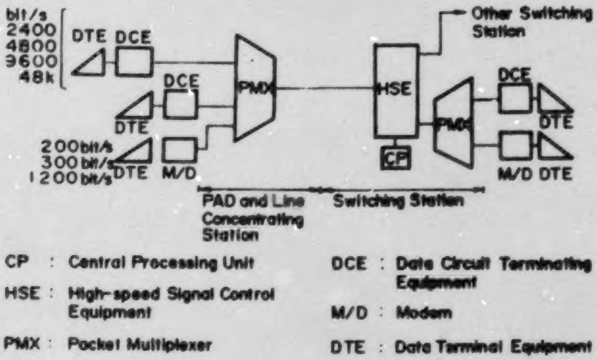
Fig. 4 DDX NETWORK CONFIGURATION

DDX network consists of two stages as shown in Fig. 5; the switching stage including toll and local switches and concentration stages. Basic system configuration of DDX-C is composed of Central Processing unit (CP), Time Division Switching Equipment (TSWE), Line Concentrator (LC), Frame Synchronization Equipment (FSY) etc. DDX-P system is composed of Central Processing Unit (CP), High Speed Signal Transfer Equipment (HSE), Packet Multiplexer (PMX) etc.



DCE
DTE
DCE
DTE
LC
Other Switching Station
TSWE
FSY
FSY
LC
DCE
DTE
CP
Line Concentrating Station
Switching Station
CP : Central Processing Unit
TSWE : Time Division Switching Equipment
FSY : Frame Synchronization Equipment
LC : Line Concentrator
DCE : Data Circuit Terminating Equipment
DTE : Data Terminal Equipment

Circuit Switched System Configuration



bit/s
2400
4800
9600
48k
DTE
DCE
DCE
DTE
200bit/s
300bit/s
1200bit/s
DTE
M/D
PMX
Other Switching Station
HSE
CP
PMX
DCE
DTE
M/D
DTE
PAD and Line Concentrating Station
Switching Station
CP : Central Processing Unit
HSE : High-speed Signal Control Equipment
PMX : Packet Multiplexer
DCE : Data Circuit Terminating Equipment
M/D : Modem
DTE : Data Terminal Equipment

Packet Switched System Configuration

Fig. 5 BASIC SYSTEM CONFIGURATION AND EQUIPMENT

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3. DDX Usage Trends, Traffic Characteristics and their Analysis

The growth of DDX subscribers numbers is shown in Fig. 6. During the first two years the growth rates of both DDX-C and DDX-P were relatively slow due to the service area limitations and insufficient provision of DTEs for DDX from manufacturers. However, rapid growth has been observed for the last two years due to increasing usage of diversified data exchange utilizing high data signaling speed.

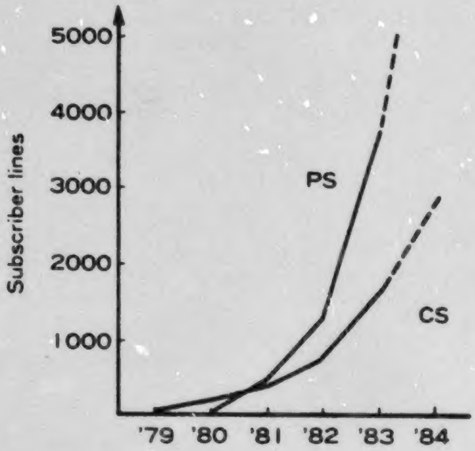


Fig. 6 GROWTH OF LINES

The annual change of data signaling rate distribution is shown in Fig. 7. The figure illustrates change of user preference and general tendency towards higher speed.

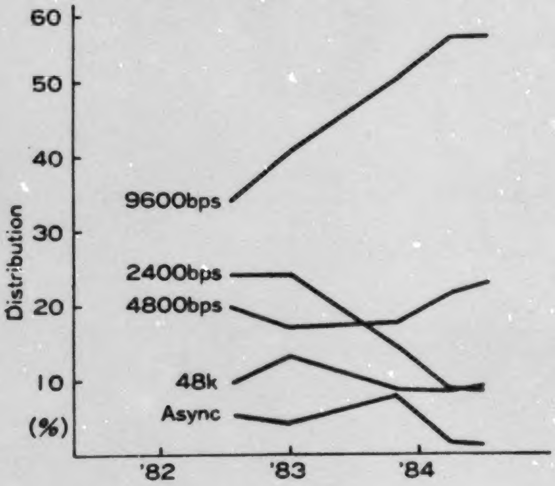


Fig. 7 (1) SPEED CLASS TRANSITION (CS)

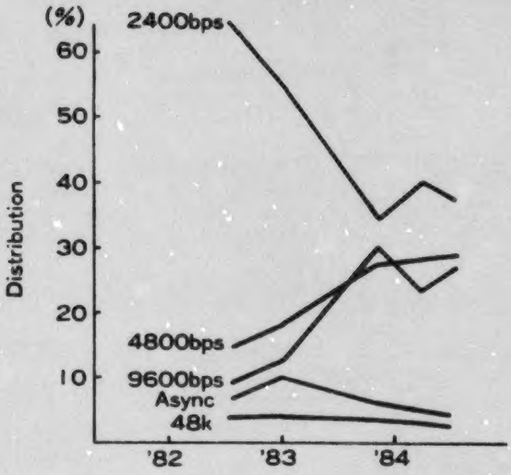
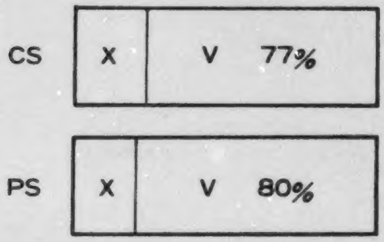
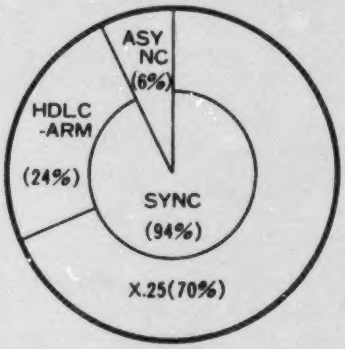


Fig. 7 (2) SPEED CLASS TRANSITION (PS)

The user preference of DTE/DCE interface shown in Fig. 8 indicates the transient state of DTE/DCE interface from conventional CCITT V-series to new X-series. About the interface protocol of DDX-P, CCITT X.25 has been major choice of users in spite of relatively affluent protocols for Non-Packet mode terminals.



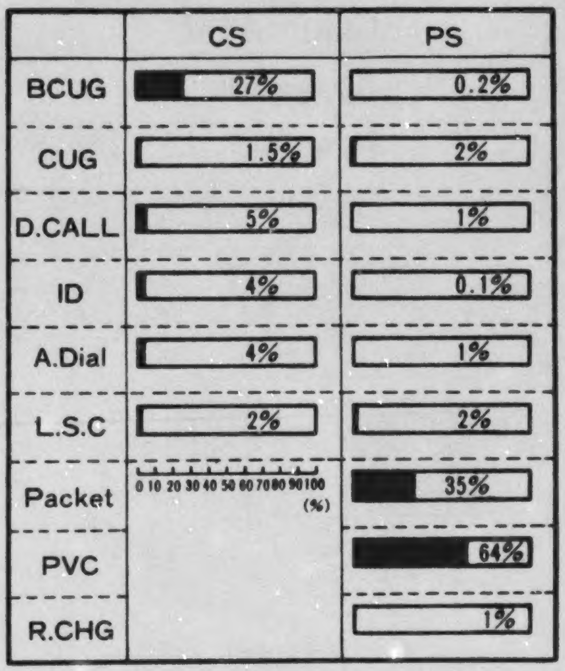
Physical Level Interfaces



Access Protocols (PS)

Fig. 8 USAGE TRENDS OF DCE/DTE INTERFACE PROTOCOL

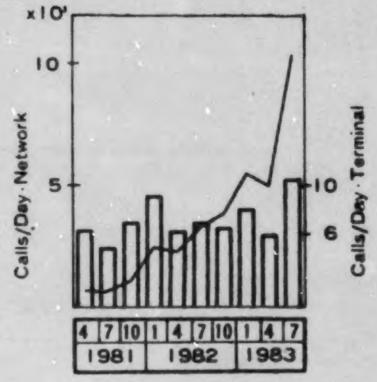
The usage ratios of various optional user facilities offered by DDX are shown in Fig. 9. The most significant usage for DDX-C is the bilateral 'Closed User Group (CUG)', which is used by 27% of the subscribers. Usage trends for 'CUG' of DDX-P are far less than that since usage of PVC service is probably sufficient for the user requirements.



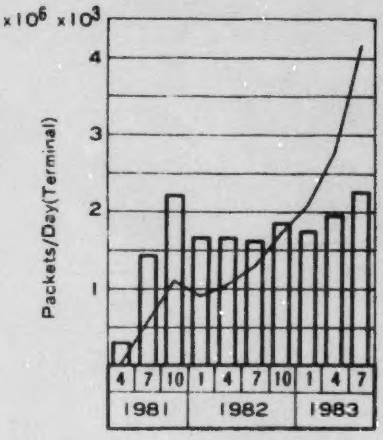
	CS	PS
BCUG	27%	0.2%
CUG	1.5%	2%
D.CALL	5%	1%
ID	4%	0.1%
A.Dial	4%	1%
L.S.C	2%	2%
Packet		35%
PVC		64%
R.CHG		1%

Fig. 9 OPT. USER FACILITIES

The constant growth trend of DDX traffic is shown in Fig. 10, adopting the measures of calls/day for DDX-C and packets/day for DDX-P. However, it is difficult to predict traffic characteristics per subscriber basis because of very rapid increase of subscribers and irregular traffic changes by subscription of big user systems with a large number of terminals.



Calls/Day (CS)



Packets/Day

Fig 10 GROWTH OF DDX TRAFFIC

Concerning the user system trends, several kinds of characteristics are emerged both in DDX-C usage and DDX-P usage as follows:

- Emergence of short-hold-mode terminal which made DDX-C applicable to the systems with low density traffic as well as those with high density traffic,
- Increasing usage of DDX-C for back-up links to other networks,
- Adaption of DDX-C for recommended intra-industry protocol of electronic money transaction between banks and other companies,
- Strong preference of higher speed classes in DDX-P users,
- Steeply increase of demands for DDX-P due to growing computer networkings.

At the beginning of DDX-P service, substancial usage of low-speed terminals was expected because of lower communication cost. However, transition to the DDX from the existing analog networks was unexpectedly small. On the other hand, most recent online realtime systems have adopted distributed processing configuration due to the recent of microprocessors suitable for higher speed class like 4800 or 9600 bps of DDX services. These are regarded an explanation of higher speed class preference.

4. Technical Developments Efforts

To meet above stated requirements of rapid network expansion and change of usage trends and characteristics, various technical development efforts on network designs and network equipments have been continued.

4.1 DDX-C

An improved D 50 digital circuit switching unit of single stage time division switch configuration, made of new LSI chips and with 64K bps transmission interface has been developed. This switch multiplexes data stream octet by octet basis at four bearer speeds, 3.2, 6.4, 12.8 and 64K bps and has the intermediate capacity of about 900 erlangs at an average speed of 9.6K bps. Also new concentrator unit with 150 connection ports and 64K bps transmission interface line card made by LSI chips has been developed, which leads cost reduction in communication port by half of the previous systems.

In addition to the improvpment of switch and concentrator unit, newly introduced LSI based digital subscriber transmission loop equipments, DSU and OCU, have contributed to reduce the subscriber loop costs, and those with X.22 multiplexed DTE/DCE interface will be introduced soon.

4.2 DDX-P

In order to economically expand the network, improved D 50 packet switching unit with two times larger packet handling capacity by using high speed D 10 processor was developed and introduced from 1981. Furthermore, newly revised packet switching unit with multi processor architecture, called D 51 Packet Switching System, has been developed and will be introduced by the end of 1985, which can facilitate both local and toll switch functions in order to cope with ever increasing demands and continuing network extension. Also, to meet unexpectedly larger demands of synchronous DTEs with higher data speed, new type of Packet Multiplexer was introduced, too.

Another improved feature was the introduction of new network access protocols such as the protocol to accommodate teletype-compatible terminals conforming to CCITT X.3, X.28 and X.29.
1980 version of X.25 will be introduced by the end of 1985 including some portion of 1984 version of X.25 such as long size packet handling.

4.3 DDX Network Testing System

In order to improve the efficiency of maintenance services for the entire DDX network and to dispatch troubleshooting action for quick fault isolation, DDX Network Testing System (DNTS), shown in Fig. 11, is planned to introduce. DNTS is intended to perform subscriber loop tests, transmission quality tests, subscriber-to-subscriber transmission quality and route monitor tests, etc. in a remote supervisory control method. DNTS is composed of processing subsystems undertaking operational management of the entire system, storage of fault history information, and information retrieval, etc. and testing subsystems stated before.

5. Network Integration Towards INS

DDX network offers the capability to transfer digital information stream regardless of its contents. Thus, DDX network has brought the possibility of integrating versatile digital services into it on the way towards the INS. In this context, various developments efforts are continued on interworking or integration of public networks with DDX.

5.1 DDX Packet Access Service via PSTN through Network Interconnection

DDX packet access service via PSTN is regarded one of the important steps towards network interworking. A special toll switch, called Toll Switching System with Data Telephone Facilities (TS-DT), and special packet multiplexer with Packet Assembly Disassembly function for calls through TS-DT are used as interworking unit.

5.2 Integration of Telex Services into DDX-C Network

Research in telex service traffic shows the comparative economy of DDX-C as the network to be integrated as illustrated in Fig. 12. Replacement of existing time worn telex network by DDX-C is planning to accomplish within three years. To accommodate existing telex terminals, newly improved D 50 circuit switching unit and new concentrator with telex service handling ability are introduced.

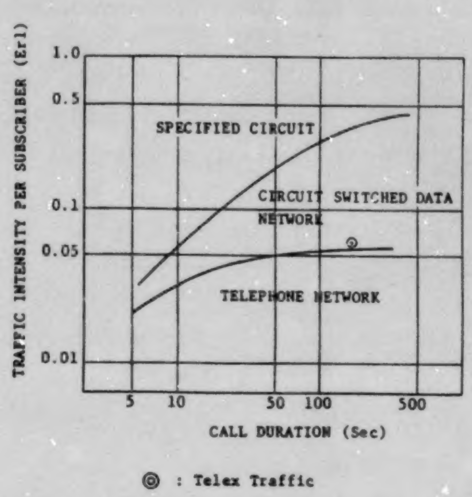


Fig. 12 FAVORABLE NETWORK FOR TELEX SERVICE

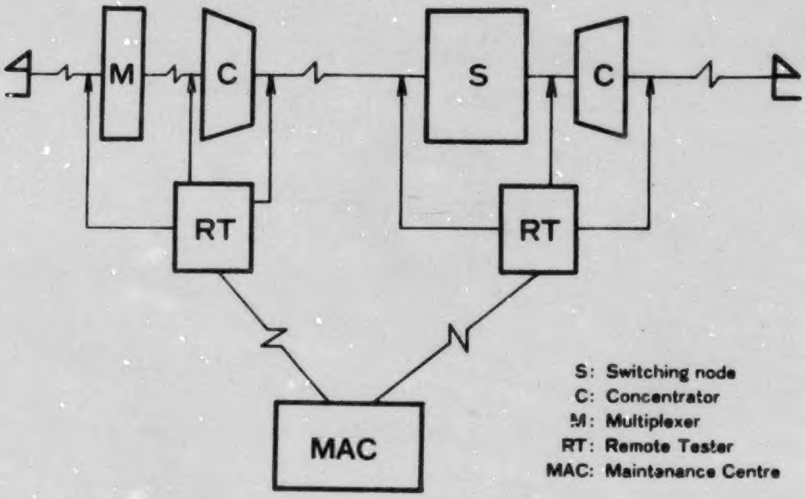


Fig. 11 DDX MAINTENANCE SYSTEM

5.3 Integration of Telegram Service into DDX-P

Through the careful analysis of telegram traffic characteristics shown in Fig. 13, the packet network was employed as the cost-effective basic transmission networks for new telegram services. Integration of the telegram network into DDX-P with telegram message handling function is now undergoing.

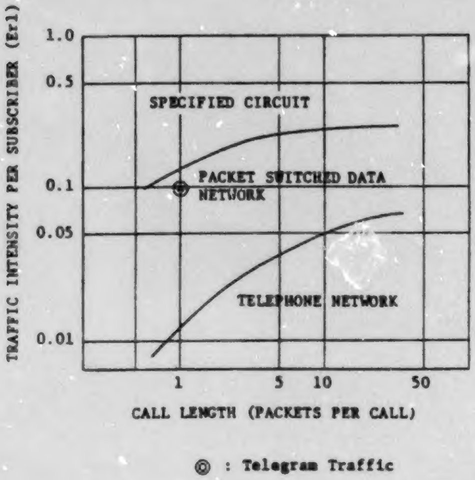


Fig. 13 FAVORABLE NETWORK FOR TELEGRAM SERVICE

5.4 Next Steps of Network Integration

As the Model System of Information Network System has started the experimental operation in Tokyo, the next step for digital network integration will be realized as shown in Fig. 14 through the following study items:

- interconnection between DDX-C and DDX-P,
- utilization of DDX for videotex and facsimile networks,
- integration of digital non-voice service networks,
- integration of digital non-voice services by the digital telephone network.

6. Conclusion

Five years operational experience of the DDX services and some perspective on the expected service situation are described in this paper, DDX was initially developed as a data communication network, then it is evolving to be the basic transmission network for non-voice communication suitable to telex, data, facsimile and videotex services.

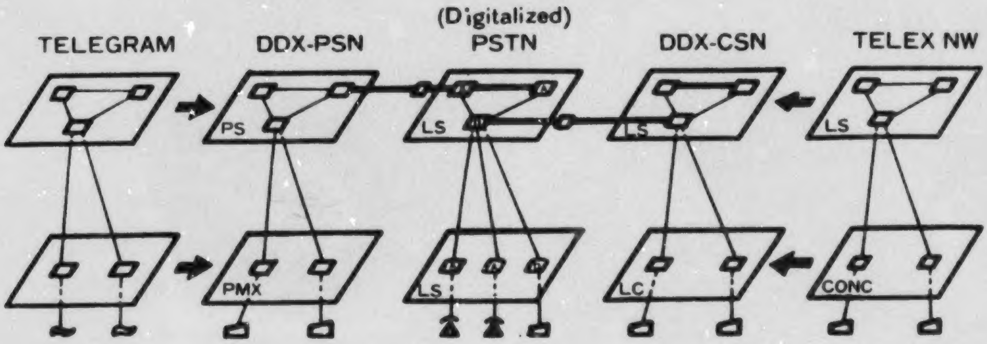


Fig. 14 INTEGRATION AND INTERWORKING

Acknowledgement

The authors wish to express their thanks to Mr. Hiroshi Itoh, Deputy Director of the Engineering Bureau, for his helpful guidance, as well as to all the people engaged in development & introduction of DDX.

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Chikara ENDOH was born in 1943. He graduated from Yamagata University, Japan, and received his B.E.E. in 1965. He has been working for NTT since graduation and joined in development of the Total Online System for Postal Saving Service. He is now Senior Staff Engineer, Director of Data Communication Network Division, Engineering Bureau, NTT.

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Integrated Services Private Digital Communication System

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FUJITSU LIMITED, Kawasaki, Japan

Abstract

In recent years, a great deal of research and development activity has centered on realizing integrated services public digital networks.

This paper describes the design concepts and system configuration of a private ISDN system that has been developed for intra-company information network systems.

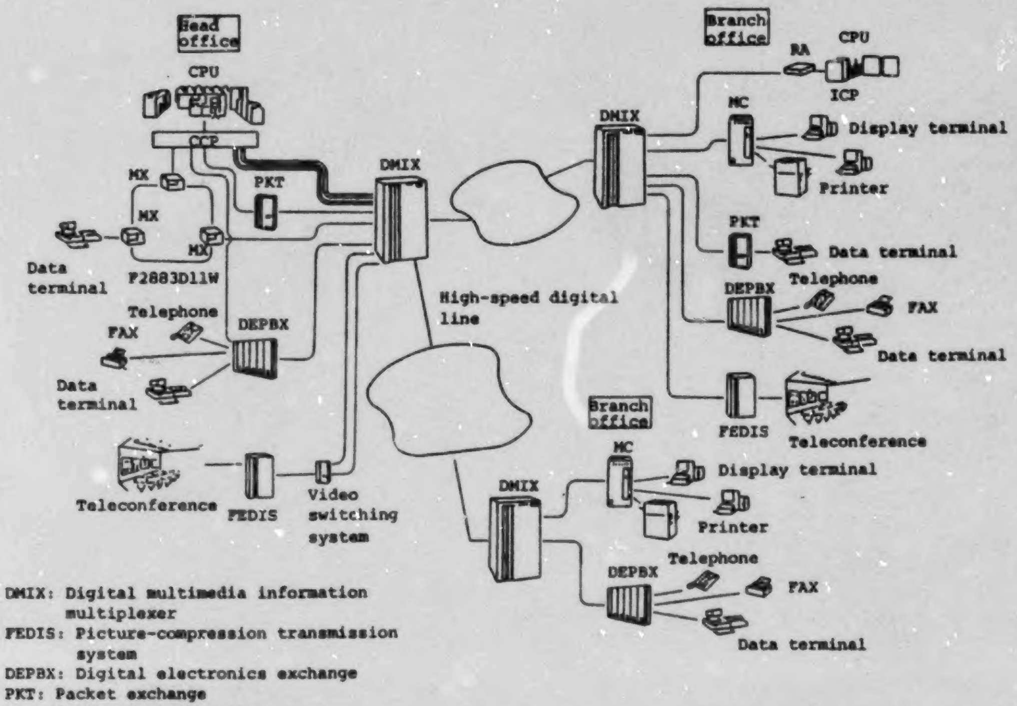
The system realizes end-to-end digital transmission, and can offer voice and non-voice integrated services. In addition, high-bit-rate digital services such as high-speed digital facsimile, bulk data transfer, and video teleconferencing are also provided.

1. INTRODUCTION

It has now become indispensable for businesses to streamline their activities. One effective method is to reconstruct intra-company communication networks to reduce rising communications costs and to integrate of multimedia information, such as data, facsimile, and telephone.

In Japan, Nippon Telegraph and Telephone Public Corporation is preparating for digital communication services by using digital trunk lines throughout the country to construct a nationwide optical fiber transmission network within the 1984 fiscal year. In addition, the organization is to start high-speed digital transmission services in the 64 kbps to 6 Mbps range and digital communication services by satellite communication from the autumn of 1984 respectively.

In these services, high-speed bulk data transmission more than 40 times the volume in the past will become possible. This paves the way for new data transmission services previously


Head office
CPU
CCP
MX
MX
MX
PKT
DMIX
Data terminal
F2883D11W
Telephone
FAX
DEPBX
Data terminal
High-speed digital line
Teleconference
FEDIS
Video switching system
Branch office
RA
CPU
ICP
DMIX
MC
Display terminal
Printer
PKT
Data terminal
DEPBX
Telephone
FAX
Data terminal
FEDIS
Teleconference
Branch office
MC
Display terminal
Printer
DMIX
DEPBX
Telephone
FAX
Data terminal

DMIX: Digital multimedia information multiplexer
FEDIS: Picture-compression transmission system
DEPBX: Digital electronics exchange
PKT: Packet exchange
MC: Display control system

Figure 1 System configuration of a private digital network

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unavailable, such as video teleconferencing and short-time video processing through CAD/CAM systems, etc.

It also becomes possible to transmit voice, data, facsimile, and video information using the same transmission line.

FUJITSU integrates this diverse information by using high-speed digital lines and provides a wide-area communication system for businesses.

The following sections describe the system configuration of a private digital network and its main component, the Digital Multimedia Information Multiplexer (DMIX).

2. SYSTEM CONFIGURATION

High-speed digital transmission lines are synchronized with a master clock signal which is unified throughout the country. Using a master-slave synchronization scheme this system forms a wide-area synchronous digital network.

Figure 1 shows the system configuration of an intra-company private digital network using the high-speed digital transmission line.

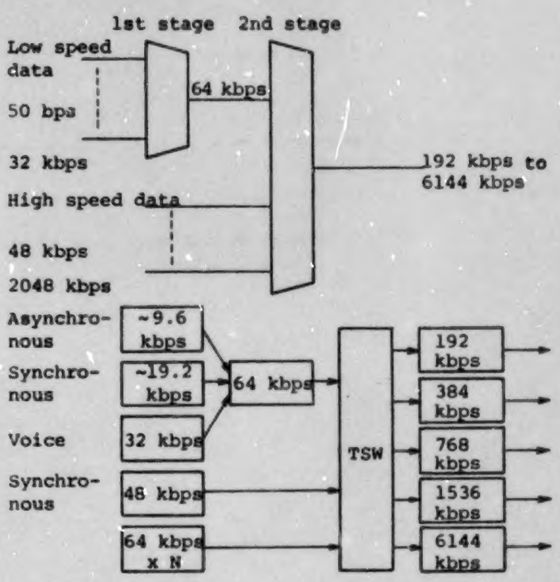
The DMIX will enable the digital transmission line to be terminated, a variety of information signals to be multiplexed, and the time slot for 64 kbps transmission to be arranged.

In addition, the equipment has multiport outputs for a network and therefore enables star connections and multi-stage cross connections, as well as of a point-to-point connections. The system can form a flexible network easily. This system has the following features.

(1) Multimode transmission
It is possible to transmit a variety of information modes, e.g., data, voice, facsimile, video, etc.

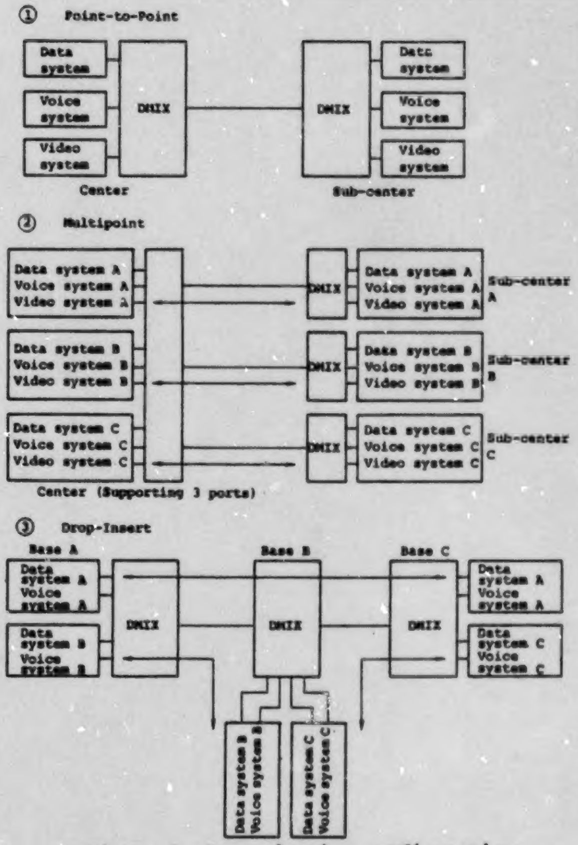
(2) Voice Transmission at 34k b/s
In addition to digital voice transmission at 64k b/s through the conventional international-standard PCM system, the system can transmit digital voice information at 32k b/s through the ADPCM system which is being studied for international standardization, thus enabling digital voice transmission of twice the volume of a conventional system.

(3) Accommodation of Remote Terminals by Using Remote Adapter
Since terminals installed at remote locations within premises can be accommodated in one place, using remote adapters, in this system, it is not necessary to provide a baseband modem.



1st stage
2nd stage
Low speed data
50 bps
32 kbps
64 kbps
192 kbps to 6144 kbps
High speed data
48 kbps
2048 kbps
Asynchronous
~9.6 kbps
Synchronous
~19.2 kbps
64 kbps
Voice
32 kbps
Synchronous
48 kbps
64 kbps x N
TSW
192 kbps
384 kbps
768 kbps
1536 kbps
6144 kbps

Figure 2 Multiplexing concept



① Point-to-Point
Data system
Voice system
Video system
DMIX
DMIX
Data system
Voice system
Video system
Center
Sub-center
② Multipoint
Data system A
Voice system A
Video system A
Data system B
Voice system B
Video system B
Data system C
Voice system C
Video system C
DMIX
Sub-center A
Sub-center B
Sub-center C
Center (Supporting 3 ports)
③ Drop-Insert
Base A
Base B
Base C
Data system A
Voice system A
Data system B
Voice system B
DMIX
Data system C
Voice system C

Figure 3 Communication configuration

(4) **Digital Connection to Digital Electronic Exchange**
Using the high-speed direct digital connection (exclusive interface) for digital EPBXs, it is possible to transmit telephone, facsimile, and data with high efficiency and high quality.

(5) Transmission of Full-Motion Pictures for Video Teleconferencing
This system can transmit digital video signals at 768k b/s when used in combination with the FACOM 2280 high-efficiency video codec (FEDIS), thus realizing a teleconferencing system with low circuit cost.

(6) Centralized Network Control
Using the network service processor (NSP), this system can supervise the system operation mode and fault conditions and put circuit construction on a centralized basis.

3. DIGITAL MULTIMEDIA INFORMATION MULTIPLEXER (DMIX)

The DMIX is capable of transmitting over high-speed digital lines flexibly, economically, and effectively not only for conventional telephone, facsimile, and data transmission, but also for new information modes such as high-speed data, high-speed facsimile, and video signal transmission, etc.

3.1 MULTIPLEXING CONCEPT

To satisfy today's increasing need for efficient communication of various information signals, multiplexing systems must be designed to enable heterogeneous multiplexing and rearrangement of the time slot used for a variety of signals.

From this standpoint, the introduction of synchronous octet-interlcave multiplexing is very attractive.

However, for a flexible network, it is suitable to use two stage multiplexing, as shown in Figure 2.

The first stage multiplexes low-speed data, less than 32 kbps bearer rate, on a 64 kbps signal.

The second stage multiplexes voice and high-speed data from 48 kbps to 2048 kbps bearer rate on a 1536 kbps or 6144 kbps signal.

3.2 OPERATION MODE

DMIX has three-mode operation as shown in Figure 3. The primary mode is the paired operation mode. The second mode is multipoint operation mode. In this case, one DMIX could communicate with a maximum of four different stations. In the third mode, DMIX acts as a three-port multiplexer which can drop or insert signals along a route without using back to back terminals.

The time slot interconnection is arranged on a 64 kbps time slot basis, permitting electrical cross-connections in DMIX.

3.3 DMIX COMPOSITION

The DMIX composition is shown in Figure 4. The DMIX comprises a common part, line set part,

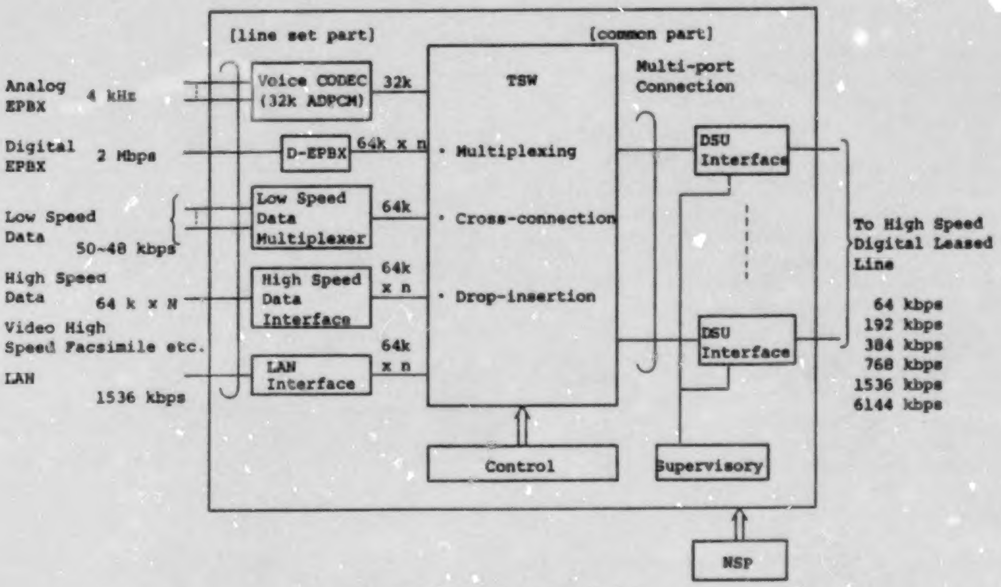

[line set part]
[common part]
Analog EPBX
4 kHz
Voice CODEC (32k ADPCM)
32k
Digital EPBX
2 Mbps
D-EPBX
64k x n
Low Speed Data
50~48 kbps
Low Speed Data Multiplexer
64k
High Speed Data
64 k x N
Video High Speed Facsimile etc.
High Speed Data Interface
64k x n
LAN
1536 kbps
LAN Interface
64k x n
TSW
• Multiplexing
• Cross-connection
• Drop-insertion
Multi-port Connection
DSU Interface
DSU Interface
To High Speed Digital Leased Line
64 kbps
192 kbps
384 kbps
768 kbps
1536 kbps
6144 kbps
Control
Supervisory
NSP

Figure 4 DMIX composition

power supply unit, and network service processor (NSP).

(1) Common Part
The common part comprises a multiplexer unit, network port, and supervisory controller unit.

The multiplexer unit receives signals from the line set part, and after allocating circuits to the 4 network ports in units of 64 kbps, using the time slot rearrangement function of TSW, it multiplexes received data on a time division basis on the high-speed bus.

This part has a duplicated configuration for reliability, and switching between the two is made autonomously.

The network port converts multiplexed signals into send signals of the high-speed digital line to transmit them to the network.

The supervisory controller unit supervises operating conditions of the network port section, sets each operation mode, and controls circuit allocation.

(2) Line Set Part
The line set part takes a physical and electrical interface according to various information modes (voice, data, video, etc.).

The voice signal is converted into a 32 kbps signal using the ADPCM coding scheme for two types of signals, analog signals and 64 kbps PCM signals.

The system converts low speed data, below 19.2 kbps, into an 8-bit envelope signal by adding 1 bit of the control signal (S) to 7 bits of data and multiplexes it into a 64 kbps signal.

The system converts high speed data, above 48 kbps, into a multiple of a 64 kbps signal.

(3) Power supply unit
The power supply unit supplies power to the common part and line set part separately. The power supply for the common part is duplicated for increased reliability in parallel operation.

(4) Network Service Processor (NSP)
The NSP centralizes control the digital network of equipment. It has 4 functions: controlling the operation mode, circuit allocation, fault condition, and maintenance/diagnosis.

The main parameters of the DMIX system are shown in Table 1, and Figure 5 shows the DMIX equipment.

4. CONCLUSION

A private information network system using high speed digital lines and equipment has been briefly described. The system provides the following benefits for businesses.

- Improves communication quality and reduces communication cost, owing to its digital transmission of data signals.
- Doubles the transmission capacity, compared with conventional systems, by using 32 kbps ADPCM CODEC for intra-company telephone networks.
- Realizes new services unavailable in the past, such as video teleconference and high-speed data transmission, etc.

This system suggests the possibility of high-level information services including telephone, facsimile, and teleconference focused based on data communication for recent developments in office automation (OA).

Acknowledgements

The authers would like to express their deep thanks to Mr. M. Ohtsuki and I. Fudemoto for their invaluable advice and constant encouragement, and other for their helpful discussion and cooperation in developing this system.

Figure 5 The DMIX.

Table 1 FACOM 2660 IMIX system parameters

Multiplexing system		Time-division-multiplexing system
Network synchronizing system		Master-slave synchronization system (Built-in OSC for plesiochronous synchronization)
High-speed digital transmission line interface		64 kbps, 192 kbps, 384 kbps, 768 kbps, 1.536 Mbps, 6.144 Mbps
Data inter-face	Asynchronous	50 bps ∿ 9600 bps [CCITT recommendation V24/V28]
	Synchronous	600 bps ∿ 19200 bps [CCITT recommendation V24/V28] 48 kbps, 56 kbps [Conforming to CCITT recommendation V35] 64 kbps, 64 kbps x N [Conforming to CCITT V11] 1.544 Mbps, 2.048 Mbps [4-W interface]
	Others	RS-449 interface
Voice interface		
(i) Analog interface		
Signaling method		DL/RG method (SS/SR method)
Coding speed		64 kbps, 32 kbps
Physical interface		(2-W/4-W)
(ii) Digital interface		2.048 Mbps
Terminals accommodated		A variety of information media, eg., telephones, data terminals, switching systems, facsimiles, and video teleconference terminals
Alarm function		Line fault and remote office alarm etc.
Diagnostic function		Various diagnostic functions, eg., loopback
Network control function		Centralized network control by network service processor
External dimensions		19-inch rack Height: 1,400/1,700 mm Width: 620 mm Depth: 880 mm Desk top Height: 330 mm Width: 480 mm Depth: 500 mm
Power supply unit		AC 100 ±10% (50/60 Hz)

COMMUNICATIONS GATEWAYS TO THE DIGITAL WORLD

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Abstract

Local access technologies provide the gateway into the digital communications world. Technologies affecting local access include the Integrated Services Digital Network (ISDN), local area networks (LANs), and a variety of concentration and interconnection techniques. Integration of these advanced technologies into public telephone company networks poses several strategic questions. This paper provides an overview of the technology trends and a discussion of the issues these technologies raise, along with alternative telephone company strategies.

1. INTRODUCTION

Within the United States, data network service revenues are increasing approximately four times faster than voice service revenues. This growth in data services is predominantly in the large business sector, where improved communications capabilities have a demonstrable effect on the corporate bottom line. At present, there is little economic incentive for small business or residential users to move beyond the communications services available from the analog dial-up network. However, the potential for new services in this sector and the prospect of such a massive market provide powerful incentives for public carriers to position themselves for eventual universal digital access.

Within the large business sector, the issue is more immediate. The number of digital devices such as digital PBXs, office automation systems, work stations, local area networks (LANs), and data terminals is rising steeply. User demand for networking of these systems and devices is also increasing steadily. Large business users want the speed and reliability of digital connection and are increasingly prepared to make capital investment in order to obtain it.

As market pressures are acting to move public network digital access outward toward the user, this shift is made possible by technology developments including pair-gain systems, multiplexers, protocol converters, packet assemblers and disassemblers (PADS), derived channel technologies, digital PBXs, and LANs. As the gateway to the digital communications world moves closer to the user, important strategic issues arise for the public telephone carriers, which have traditionally seen universal voice communications as their primary focus.

2. THE TECHNOLOGIES

2.1 DIGITAL PAIR GAIN SYSTEMS

Digital pair gain technology is well established in the United States. Originally deployed in rural areas to save copper, pair gain systems now provide over 20% of subscriber line growth, and offer substantially reduced operating costs. Although initially designed as an access system for voice, present technology allows provision of data services as well. Because these systems improve the efficiency of the local loop by locating digital electronics in the distribution plant or on customer premises, they effectively move the digital interface closer to the user. Pair gain technology is relatively mature, and is not software intensive.

2.2 DERIVED CHANNEL SYSTEMS

Derived channel systems are designed to provide multiple channels on a single copper pair. An example of this technology is data-above-voice, which uses the spectrum above the voice band to derive a full duplex data channel. A device on the customer premises separates the voice and data channels with passive filters. At the central office, a similar filtering function is performed, with the voice routed to the voice switch and the data routed to a packet switch or digital cross-connect.

A promising application for derived channel technology may be to provide users with access to a packet switched network without additional wiring or disruption of telephone service. Several operating companies in the United States are currently implementing data-over-voice technology congruently with a public packet switched network. Other uses of derived channel technologies include alarm services, energy management, meter reading, pay-per-view television, and teletext. Present derived channel systems are not software intensive.

The Integrated Services Digital Network (ISDN) is an example of a future derived channel technology. As shown in Figure 1, a standard interface to an end-to-end digital telephone network would enable

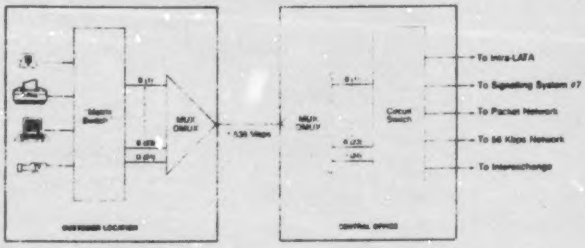

Figure 1 — Possible ISDN architecture. D channel is 16 Kbps used for signalling. B channels are 64 Kbps each used for data. D channel would be used to establish connection and order bandwidth for data up to 1.536 Mbps in 8 Kbps increments.

the user to access voice, video, facsimile, and data services with bandwidth allocated flexibly on demand. Numerous unresolved technical and legal issues exist regarding public network implementation in the United States. In addition, ISDN is the subject of ongoing standards activity in the CCITT and other domestic and international standards bodies. This developing technology is a dramatic illustration of derived channel systems moving the digital interface outward toward the user.

2.3 ADVANCED CONCENTRATION TECHNOLOGIES

Advanced concentration technologies include such categories as digital multiplexers, PADs, and data compression algorithms. The primary purpose of devices using these technologies is to optimize the available bandwidth of a single channel.

Time division multiplexing (TDM) is a basic form of multiplexing multiple digital inputs onto a single output channel. This well-known technique is commonly used within telephone and data networks. Statistical multiplexers are less common and more sophisticated. Whereas TDM systems will provide a predetermined portion of the available bandwidth to each input, statistical multiplexers provide bandwidth dynamically only to those inputs which are active. Pauses and silent periods are effectively ignored. If the data transmission is bursty, as is often the case in many of today's data applications, statistical multiplexers will allow the summed baud rates of all inputs to significantly exceed the baud rate of the output channel.

Multiplexers can be operated as stand alone devices, or they can be integrated with other concentration technologies such as data compression devices or PADs. Data compression technology recodes digital data to reduce information redundancy. The compressed data requires less bandwidth for transmission than would the raw data. PADs packetize and convert the protocols of the incoming data so that data from dissimilar devices can transparently communicate through a packet switched network.

State-of-the-art concentration devices are software driven and use algorithms which may not be standardized. These devices can be used on either or both ends of the local loop; however, a state-of-the-art network would place them on the peripheral end in order to optimize use of the loop. Here again, the technology providing the communications gateway to the digital world is moved outward toward the user. Advanced concentration technology is typically more sophisticated than that used in pair gain or derived channel systems, and offers considerably more flexibility in networking applications.

2.4 LOCAL AREA NETWORKS (LANs)

A local area network may be defined as a network which allows dynamic interconnection of similar or dissimilar data terminals within a building or restricted geographical area, using shared transmission resources. LANs are designed for state-of-the-art applications and vary considerably from application to application. Some are designed primarily for high speed host-to-host communications. Others are designed primarily for terminal-to-host or terminal-to-terminal connections. They use a variety of topologies (ring, star, etc.), access methods (e.g., token passing and CSMA/CD), and transmission media (twisted pair, coaxial cable, and fiber optics). Some LANs are designed for integration with voice; most are data only. The largest potential market for LANs may be as a communications backbone for the automated office.

LANs may be viewed as geographical extensions of the computer bus serving multiple processors. In this light, LAN technology is often closer to the communications modules of computer systems than to standard telephone company equipment. As will be discussed in more detail below, this poses a special dilemma for telephone companies. LANs are specialized distribution/switching systems which use advanced technology to place the gateway to the digital communications world on the doorstep of the user.

2.5 PRIVATE BRANCH EXCHANGES (PBXs)

The PBX is well established as a circuit switch located on the customer premises. The newest generation of PBXs is digital and can support data circuits. In terms of long range prospects for data communications, there is considerable discussion as to whether the PBX or the LAN will predominate. Some believe that the two technologies might eventually merge. Presently, PBXs are used extensively to extend central office switching technology to the customer premises.

3. TELEPHONE COMPANY ISSUES

As the point of digital access moves closer to the user, a variety of strategic issues face telephone companies. One involves legal and regulatory restrictions. Although these restrictions are peculiar to the United States, their effects may be more globally felt. Another group of strategic issues involves engineering, systems analysis, and operations. These issues may be the most critical in the long run.

3.1 LEGAL

The legal restrictions discussed here directly affect only U.S. operating companies, and even here, the smaller independent companies are not fully impacted. However, the greatest number of advanced data processing and data communications applications are in the U.S. market. The greatest concentration of these applications are within areas served by the former AT&T Bell Operating Companies (BOCs). The BOCs are under numerous regulatory and legal restrictions, and their response to these pressures will affect the direction of communications networks worldwide. At present, the impact of regulatory restrictions is greatest in the large business market.

Present law precludes the BOCs from providing customer premise equipment (CPE). Although CPE has been defined as equipment located on the customer's premises, there are many gray areas. For example, the BOCs may still provide multiplexers, but not digital network channel terminating equipment (NCTE). Although the Federal Communications Commission has explicitly precluded the BOCs from providing digital NCTE, it has yet to so restrict the provision of analog NCTE. Even the definition of NCTE is somewhat unclear.

The BOCs are also prohibited from offering "enhanced services." The definition of enhanced services is again not clear cut. The law appears to permit the BOCs to provide a transmission pipeline such that information exits the network unchanged from its entry. This is a simple concept, but complex in practice. Protocol conversion provides an example of the confusion. Protocol conversion may repackage the information content of the user's message, but does not alter it. It does, however, alter the overhead and administrative information contained in the headers, address fields, error check fields, etc.

Thus, the status of protocol conversion as an enhanced service is highly controversial. Since protocol conversion is an integral part of the more advanced LANs, the regulatory status of LANs is uncertain from an enhanced service standpoint. Digital PBXs, particularly if they begin to integrate LAN functions, could also face uncertainty as an enhanced service in addition to their present prohibition as CPE.

The CPE and enhanced services issues are likely to keep lawyers busy for a long time. From a technologist's standpoint, the key word is uncertainty. It is the highly advanced technologies which partly or wholly reside on customer premises which are most at risk. The overall effect of present legal restrictions on the BOCs is to restrict local carriers to providing a more or less hollow communications pipe to the user. Although this pipe may be digital end to end, regulation might require much of the advanced communication technology to reside outside of the U.S. public telephone networks as the gateway to the world of digital communications moves out toward the user.

3.2 ENGINEERING, SYSTEMS ANALYSIS, AND OPERATIONS

Legal restrictions aside, the advanced communications technology required to bring the digital gateway to the user's premises raises significant issues for public telephone companies. These issues stem from the complexity of the technology environment of the large business customer. These users face a multitude of complex problems. Their communications network is often a critical aspect of their business. The technology is rapidly evolving, and there are many vendors whose products must be assessed. Standardization is not always what it should be. Advanced telecommunications equipment is software intensive, and evolving software intensive products often have bugs which show up as intermittent, hard to diagnose errors that make maintenance tricky.

The communications technology may be highly interdependent with the data processing technology and the company's computer applications. Thus, expertise in the company's computer technology and data applications is necessary to engineer, implement, and operate the communications network. This is a complex environment to master, even from the user's inside position. It is even more difficult from the outside position of the vendor. Computer vendors, as sellers of packaged technology, have struggled with this environment for some time. Telephone companies, on the other hand, are traditionally buyers of technology and sellers of service. Historically, they have not involved themselves on a day-to-day basis with the complex and customized technology environment of the large business operation.

It is an open question whether telephone companies will or should become technology vendors. Users in all market sectors would prefer that a single vendor accept end to end responsibility for their communications systems. Otherwise, the user's capital investment in equipment and personnel can become uncomfortably large. From the telephone company's standpoint, it seems likely that bandwidth will eventually be provided at low profit. Higher returns are likely to go to sellers of technology and high level technical expertise. Thus, the traditional telephone company position as a seller of service could lead to market and/or technical stagnation. On the other hand, telephone company involvement as a vendor of technology and technical expertise would entail expansion of their historical business role as service vendors. Such expansion would involve acceptance of additional risk by the company, the users, and the regulators.

4. STRATEGIES

Figure 2 summarizes the present environment. Market pressure and the trends of technology development are acting to move the communications gateway to the digital world toward the user premises. Legal restrictions in the U.S. are slowing this development by preventing full participation by the BOCs. This forces users to make capital investment in privately owned and operated equipment, a move they will make hesitantly. The telephone company's traditional business role as service vendor is also acting against the trend. Worldwide, this may be the major force; however, this factor is not fully engaged in the U.S. Here, the regulatory restrictions partially shield the BOCs by limiting their strategic alternatives in key areas. From this discussion, it should also be clear that the near term trends may differ between U.S. and foreign telephone companies. This is cause for concern from the standpoint of international internetworking, equipment development, and standardization.

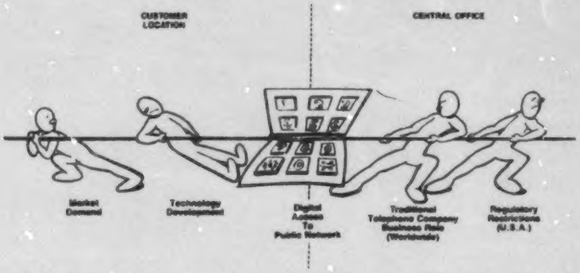
CUSTOMER LOCATION
CENTRAL OFFICE
Market Demand
Technology Development
Digital Access To Public Network
Traditional Telephone Company Business Role (Worldwide)
Regulatory Restrictions (U.S.A.)

Figure 2 — Shows forces presently acting on the migration of digital access to the public network toward the customer location.

4.1 PASSIVE STRATEGY

Several strategies are available to the telephone companies. A passive strategy would call for the introduction of new technology only when it would lower costs. Technology would not be implemented to develop new markets or to protect the revenue base. Most of the leading edge technologies would then be developed primarily to reside outside the public network. In a highly competitive environment, users would have leading edge communications only if they could both justify and afford the capital outlay. Assuming that such capital outlay will be increasingly justifiable, the telephone companies would have a shrinking user base as the public network was bypassed in favor of more advanced technology. In a less competitive environment, a leading edge communications network would be slowed or prevented from developing. It should be noted that this is a low risk strategy in terms of capital investment by the telephone company. In addition, the present depth and quality of public telephone company experience, knowledge, and expertise worldwide is sufficient to carry out this strategy.

4.2 AGGRESSIVE STRATEGY

This strategy would place telephone companies in the role of vendors of technology, and would have them engineering, implementing, and maintaining sophisticated software intensive equipment such as state-of-the-art LANs on customer premises. In a competitive environment they would find themselves in direct competition with computer vendors, LAN vendors, and other marketers of high technology. In all environments, this strategy would provide the most rapid availability of state-of-the-art communications networks. It also has the best chance of protecting or expanding the telephone companies' user base. However, this strategy requires a relatively high capital investment and corporate risk. In addition, as discussed previously, telephone companies have traditionally been users of technology and have little experience as technology vendors. Considerable expansion to the traditional telephone company business role is therefore required. Finally, in the United States this strategy runs counter to the present regulatory environment.

4.3 INTERMEDIATE STRATEGY

There are numerous middle course strategies. These strategies have in common the characteristic of leading to more advanced communications services, without the telephone companies actually marketing technology. In the case of LANs, for example, the telephone companies could downplay direct involvement in the LAN market, emphasizing instead a diversification into LAN interconnection. As illustrated in Figure 3, this might be done via a high speed backbone network, possibly fiber based, technologically capable of efficiently interconnecting LANs into larger metropolitan area networks. Thus, advanced network gateway services would be sold as opposed to LAN technology. Another middle course strategy is ISDN. ISDN will use technology within the network to provide advanced digital services to the user.

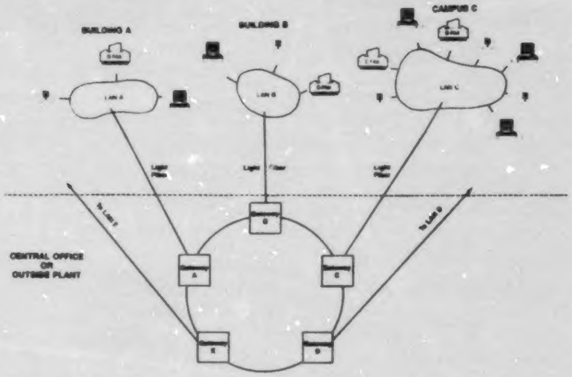

Figure 3 — Shows interconnection of LANs into metropolitan area network (MAN). Network gateways contain intelligence to allow dissimilar LANs to communicate.

5. CONCLUSION

In the United States, telephone companies presently appear to be pursuing middle course strategies. There is a growing commitment to ISDN. There also appears to be a willingness among the BOCs to actively contest those regulations which push them into a passive position. Should regulation soften, it might be expected that some BOCs would venture out with aggressive strategies. Others would be likely to stay with the middle course. With the rapid development of technology and the present competitive environment, passive strategies are less likely due to the risk of significant losses in the user base. Outside the U.S., any of the three strategies might be appropriate depending on short and long term goals, willingness to assume risk, and the technical expertise available.

NOTE: The ideas presented in this paper are those of the author and do not represent a commitment by Pacific Bell to any service or course of action.

ISDN FEATURES REQUIRE NEW CAPABILITIES IN DIGITAL SWITCHING SYSTEMS

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ABSTRACT Some of the data features expected to be a part of the ISDN (Integrated Services Digital Network) future exhibit grossly different traffic characteristics than telephony traffic, ranging from very high traffic levels to very high call attempt levels. This paper will define these characteristics and explore their impact on conventionally designed central processing systems and traditional TS(N)T switching networks. Traffic bottlenecks will be identified in the earlier systems which will limit their effectiveness to support ISDN features. Finally, an architecture is described which completely avoids those bottlenecks, serves fully the ISDN switching requirements, and provides numerous other advantages for the Telephone Administration as well.

1. ISDN SWITCHING REQUIREMENTS

While the actual features that will be part of the ISDN world are not totally identified yet, There are some very important traffic characteristics that are sure to be included, and these characteristics have a severe impact on the design of central office switching systems. Figure 1 shows how they differ significantly from those for pure telephony.

Telephone offices have been designed for the area in the figure labelled "voice." That is, an average subscriber around the world makes one or two call attempts per busy hour (BHCA = Busy Hour Call Attempt), and the holding time (HT) per call ranges roughly from 90 to 200 seconds. There are, of course, countries where the attempt rate is as high as 7 or 8 calls per hour, and holding times down to 50 and 60 seconds.

We, as suppliers, used to think these extremes were difficult to handle. Now, let's consider the rest of Figure 1.

While it could be expected that the variety of future services and differing needs of individuals could fully populate the figure below the 1 Erlang line, it is most interesting to look at the areas which represent the biggest challenges for switching system design.

At the upper left hand corner, there is an area labelled "Local Interactive Data," characterized by long holding times, and therefore lower calling rates. Some examples of this type of service might be a time-sharing access into some large computer, transfer of very large databases, or even two computer games players challenging each other via the telephone lines. This phenomenon will occur more frequently in areas that have flat rate charges per call, but probably will be a significant part of ISDN everywhere. The impact on switching systems is that where telephone switches have been designed to handle (nominally) 0.1 Erlang per line, and 0.8 Erlang per trunk, the network of an ISDN switch will need to adapt easily and economically to traffic levels approaching 1 Erlang for each terminal.

As an aside, there is increasing pressure to put so-called Private Line Services (dedicated point to point service between preset hours/days) through the switching systems to save administrative costs. These connections at 1 Erlang have a similar characteristic as above.

At the lower right part of the figure, we see two (possibly overlapping) areas labelled

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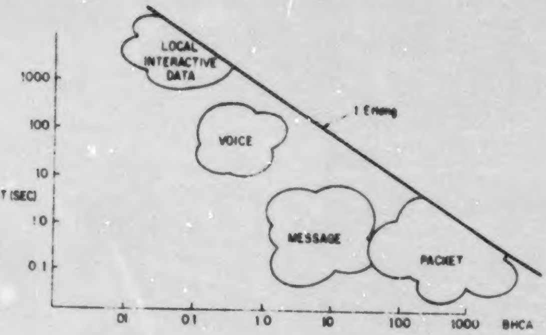


Figure 1. Changing Traffic Patterns for ISDN.

"Message" and "Packet" switching. Message Switching is here defined as a simplex or duplex path that exists only for the duration of passing (and probably checking) of a single message. As terminals get more intelligent, they will be able to avoid the nonproductive time of a full-time interactive connection, for example, to a computer. These paths will only exist when information is actually being transmitted. As the Information Revolution expands, we can foresee a very large increase in this type of traffic for applications too numerous to mention. The impact on switching systems will be very high calling rates, even at moderate traffic levels. A. Rosner [1] predicts that holding times will be measured in milliseconds, with the attendant calling rate thousands of times higher than for telephony. The control structures, both for call handling and switching network, will need to cater to these levels.

Packet switching is a rather complicated technique for improving the cost effectiveness of carrying longer messages when there is no real time urgency. In simplification, low priority messages are accepted, broken down into submessages of a maximum length (packet), assigned a priority, and stored in memory. The packet switch then dispatches these packets according to priority, going to lower priorities when there are no messages of higher priority to be sent. Most low priority messages are delayed until low traffic (night) time in a well used system, but it can be shown that significant cost savings in transmission facilities can be accomplished.

What is interesting is that if ISDN is to fulfill its promises of economies and wide access among different services, the local exchange, at minimum, will need to serve as a concentrator and PAD (Packet Assembly/Disassembly) point between continuous terminals and specialized packet facilities. This also will provide high call rate requirements on the switching systems control structure.

The magnitude of the differences in switching system requirements for the ISDN world compared with present day telephony should be clear. Whereas today, telephone exchanges are designed for a relatively tight cluster of values around 1 BHCA and 0.1 Erlang per line, ISDN will require tens to hundreds of BHCA and approach 1 Erlang for some lines. There is considerable evidence that conventional switching structures will be hard pressed to accommodate these characteristics economically.

2. LIMITATIONS OF CONVENTIONAL SYSTEMS

The previous statement about conventional systems not being well equipped to take on the ISDN future is a strong one. What is it about "conventional systems" that create this concern? The answer is in three parts:

1. The conventional systems have a call handling control structure based on a central processor (CPU) [2], or a finite number of processors in a multi-processing configuration [3];

2. The conventional systems have networks whose control is based upon a "map-in-memory" technique which uses the central processor(s) to find an idle network channel;

3. The conventional systems have networks based on TST (T = Time Switch, S = Space Switch), TSST, or STS structures, which being relatively expensive, do not provide the flexibility to easily accept 1 Erlang terminals in significant numbers.

The last point is perhaps less important because it should be relatively simple to modify conventional designs to provide additional spare capacity. Rather than the common 240 channel to 256 channel (or 480 to 512) expansion in most designs, it could be easy (maybe expensive) to provide almost a 1:2 expansion which would cater for the high traffic lines and trunks that may be part of the ISDN network.

Regarding the call handling control structure, Figure 2 shows a generalization of "conventional" systems. In generic terms, a "signal processor" (SP) takes over many of the real time functions of call handling, namely scanning and driving. Usually, a number of SP pairs are provided, each serving a relatively large number of terminals. Telephonic events occur relatively slowly and are responsible for the ratio of terminals to SPs. Given the much higher calling rates for ISDN service, the SPs can be a bottleneck for handling the possible calls generated/received by ISDN terminals.

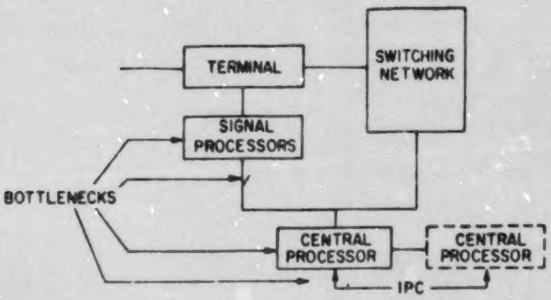


Figure 2. Conventional CPU Control Systems.

The central processor handles the remainder of the call control functions, namely call handling logic, translations, allocation of exchange resources (trunks, service circuits) to calls, and network control. These are sized in a number of ways to adapt to the variety of capacity requirements in a given country's network. Some suppliers advocate a single central processor type, regardless of the size of the exchange. (This has to be relatively expensive when the exchange is small.) Others advocate multi-processor configurations which allow for better economics over the life of the exchange; however, all of these have a fixed upper limit on the number of processor pairs because of hardware or packaging limitations. Thus, the traditional multi-processing scheme has similar throughput limitations as other CPU systems. Finally, more suppliers are shying away from multi-processing schemes because of their complexity, and advocating different capacity CPUs for different sized exchanges. Not considering that a conversion of processors from one size to another is a difficult and service endangering task, there still is an upper limit on the call handling throughput that such designs can accommodate.

Finally, consider the bus systems connecting the CPU with the rest of the system. Bus systems have three types of problems. Because they extend over a large number of physical units, they are subject to faults, and are difficult to extend in a working exchange. Also, they have a finite message carrying capacity. In Figure 2, we can see a CPU bus that extends to a relatively large number of signal processors and to the switching network. For telephony applications, this bus is designed to handle comfortably all the messages required among these units, but what happens when the calling rate increases significantly as a result of ISDN services? Bus congestion, further limiting the throughput of the system.

Note also that in multiprocessing systems, there is a need for interprocessor communication (labelled IPC) to hand off calls from one processor to another. This is another point of potentially severe congestion as the calling rate increases dramatically.

Regarding the second point earlier, that of network control (see Figure 3), conventional systems utilize the map-in-memory approach to keep track of the busy/idle status of the switching network's internal links. This map is usually held in the memory of the central processor. Given a request for a network connection, the CPU has to look in memory at the status of a number of links and make a selection of a complete idle path. Also, when the path is released, it has to update the status in memory of all network links involved. Whereas this might be an acceptable task for a telephony switch, when the path connection and tear-down activity increases by a factor of 10 to 100 or more, the CPU will become completely bogged down and limit the number of calls that can occur.

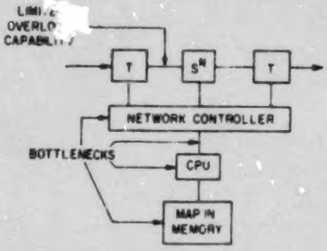


Figure 3. Conventional Digital Switching Networks.

There is a consensus that call processing requirements, just for telephony, increase every year because of the addition of subscriber and administrative features. One source [4] puts this conservatively at 5% per year. This means, independent of ISDN considerations, that if a central processor is capable of handling 40K lines today, fifteen years from now it will serve less than 20K lines. Overlay on that the severe requirements of ISDN and it is easy to see that CPU systems have severe limitations, no matter what the size.

We have just considered the impact of feature evolution without ISDN. How can we get a handle on the effect of ISDN on central processing systems? Consider the following assumptions:

1. The central control mechanism is assumed to be only a queuing machine; that is, there is no contribution to service delay caused by work time.

2. Because of the short holding times of some types of data calls, the switching delays will have to be much less for these data calls than for telephony.

3. Ten percent of the terminals will be ISDN terminals.

4. ISDN terminals will provide five times (very conservative) the calling rate of telephony lines.

5. From 2, we further assume that if a telephony delay of X is acceptable, delay for data will be X/10. (Example: dial tone delay for telephony - 400ms; for data - 40 ms).

Using these assumptions, we can show that a CPU system that can serve 40K lines for telephony will be able to serve less than 22K lines for ISDN (Figure 4). This comes from a twofold effect; in order to guarantee the grade of service (GOS) required by data lines, you need to reserve more of the processor real time as spare to handle the peaks of traffic; this takes away from usable real time. Second, ten percent of the lines have a 5 times calling rate, which uses much more real time per line, leaving less for telephony subscribers. This is only a first order approximation; the actual situation may be even worse.

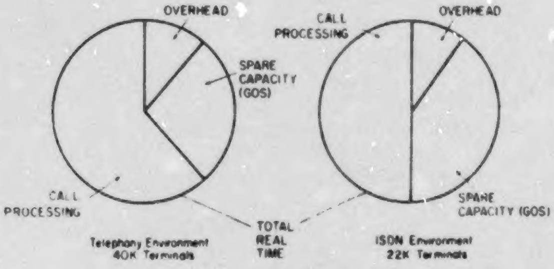


Figure 4 Effect of ISDN on CPU Terminal Capacity.

Now that we have identified the bottlenecks in traditional systems, how do we avoid them? The answer is, we borrow techniques from switching systems from the pre-CPU days to distribute the control and eliminate central processors.

3. SOLUTION TO TRADITIONAL SYSTEM BOTTLENECKS

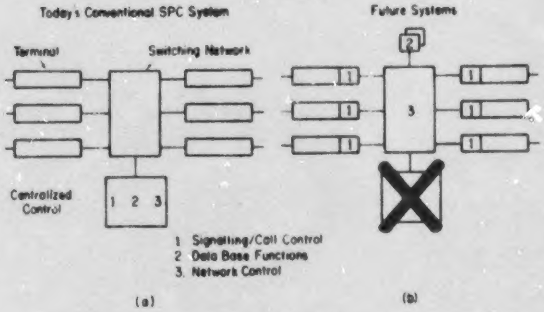
Figure 5(a) shows a simplification of central processing systems. Three critical functions are consolidated in the CPU:

1. Signalling/call handling;

2. Data Base Functions (translations, etc.);

3. Network Control.

To eliminate the bottlenecks of CPU systems, we have to distribute these functions in a different manner. Figure 5(b) shows this distribution. The signalling/call handling functions are allocated to the terminal modules themselves. From a signalling point of view, these may appear like the signal processors of traditional design. However,to avoid the traffic bottleneck limitations, we need to go much further. The control for the terminal modules also provides all the call handling functions; there is no central call handling processor. Under fully distributed control, a processor providing the signalling/call control function would do so for a very limited number of terminals, preferably one, in order to guarantee sufficient capacity to serve any requirement in the future.



(a)

(b)

Figure 5. Required Relocation of Functions to Eliminate Bottlenecks.

The database functions should be allocated to a pool of resources, not just one nor any limited number, but a continuously expandable pool such that increasing requirements can always be handled by adding additional resources. The objective is to make this an

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engineerable quantity such that the necessary grade of service can be guaranteed at essentially any size and calling rate. Finally, these database resources should appear at ordinary terminals on the digital switching network in order to assure full accessibility and availability to the call handling control units, and to eliminate the problems of busses.

Finally, the network control function should be incorporated within the network fabric itself such that the control units at the network terminals can send information into the network on the digital channels, and the network accomplishes the required connection without further interaction. To eliminate the bottlenecks of traditional networks, there should be no centralized map in memory, and there should be no limitations on the number of paths that can be set up and released simultaneously. These characteristics are mindful of a step-by-step/Strowger network which is controlled from the terminals, and which can autonomously set a path whenever one is available.

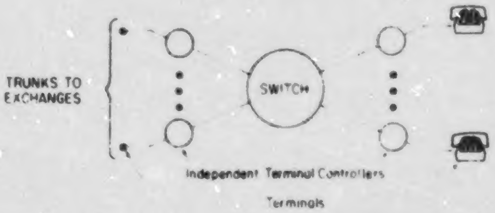
Thus, we have eliminated all the bottlenecks inherent in traditional CPU structures, but we have also eliminated the CPU with which we had become familiar. Somehow, it was comforting and occasionally useful to have an intelligent control unit that knew everything that was going on in the exchange. But is that all-knowing control unit essential to the exchange switching task? How can the distributed control concept work to handle calls successfully?

The answers to these questions are, respectively:

- A central processor is definitely not essential in a telephone exchange. We have but to look at the switching systems designed before CPUs were available to realize this.
- The concept of call handling in the fully distributed control architecture we have just described is remarkably simple, as we shall see in the next section.

4. CALL HANDLING UNDER FULLY DISTRIBUTED CONTROL

In terms of what it has to do, one can specify the requirements for a switching system in a relatively few words. It must, on receipt of instructions from originating terminals, make a variety of telephone connections between a group of terminals, usually two, sometimes three, rarely more. It must do this with a required quality of service. It must provide continuous or nearly continuous operation, as experienced by the average subscriber. It must be able to provide charging information to the Administration. It must be able to interface with existing equipment in the national network. It must be able to handle day to day changes in configuration, and larger changes required for expansion. Etcetera. The point is, seen from the point of view of what the exchange has to do, Figure 6 shows an elegant solution to the telephone exchange switching problem.



Terminal Controller provides three functions
1 Completely controls its terminal
2 Controls connections through switch to other Terminal Controllers
3 Cooperates with other Controllers through signalling to make the telephone connection
(Analogous to interworking of two exchanges)

Figure 6. Distributed Solution to the Telephone Exchange Problem.

The key to this structure is the concept of a terminal controller that needs to do just three things to make telephone connections:

1. It needs to be able to completely control its terminal; that is, it must be able to receive, interpret, and send signals from/to a subscriber telephone, or in the case of a trunk, interwork with the neighboring exchange via the given signalling system. In concept, this terminal controller provides all call handling and database functions required by the terminal.
2. It must cause connections to be made through a switching network to connect to another terminal controller.
3. It must be able to communicate and co-operate with the other terminal controller to accomplish the telephone connection. This last capability is exactly analogous to two independent exchanges cooperating via whatever signalling system to accomplish an inter-exchange connection.

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These three capabilities of a terminal controller are crucial to understanding how a fully distributed control exchange, already postulated as being necessary for ISDN, can actually work. The analogy between the independent terminal controllers and independent exchanges really makes it all work.

The simplicity of the above requirements for the terminal controller supports the claim of being an "elegant solution" to the telephone exchange switching problem. However, there are some powerful implications in the required capability of the "terminal controller":

1. It theoretically could be implemented by a microprocessor per terminal;

2. Some database functions (e.g., allocating trunks or service circuits to calls) require more knowledge than would be available to an individual terminal controller; and

3. Each terminal controller becomes equivalent to a mini-exchange, with all the implications of program and data storage requirements.

5. A CURRENT IMPLEMENTATION OF FULLY DISTRIBUTED CONTROL

Today's costs for microprocessors and memory do not allow the implementation of the "terminal controller" in a single microprocessor per terminal. However, if one were to take the different detailed functions of the terminal controller, distribute them among several microprocessors, and ensure that each microprocessor is lightly loaded to guarantee rapid response times, an independent terminal controller could be devised whose operational characteristics would be much superior to CPU systems which rely on elaborate operating systems and waiting queues to achieve a high call throughput.

Figure 7 shows a current implementation of a fully distributed system. A terminal processor serves 128 lines or 30 trunks, and provides a limited set of the terminal controller functions, basically the real time intensive functions.

An auxiliary call processor works with 4, 6, or 8 terminal processors and provides most of the remaining functions of the terminal controller. Left out are the database functions for two very good reasons:

1. It would be inconvenient for administrative reasons to have a very large number of copies of translation tables because of constant update requirements.

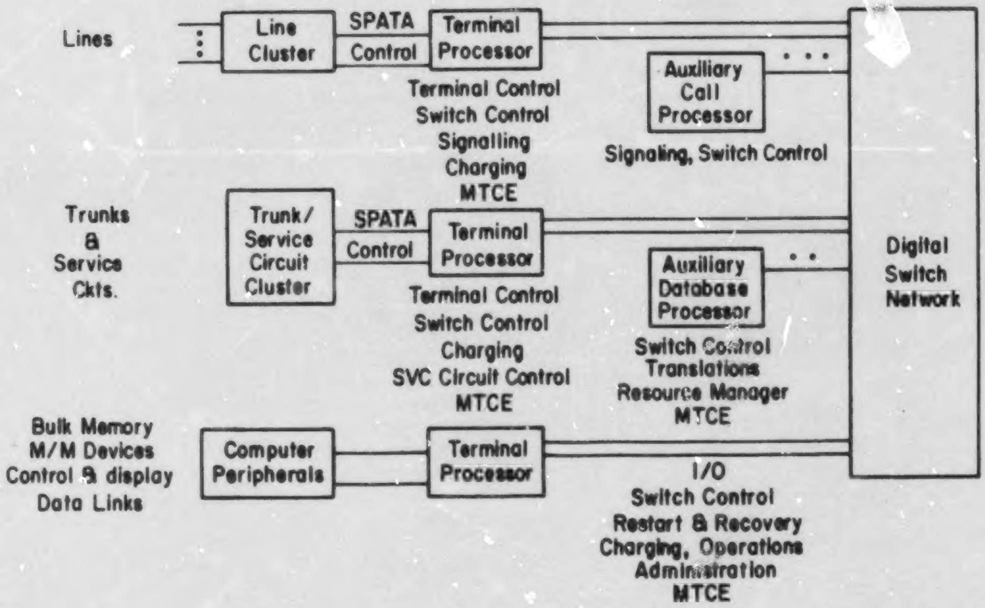
Lines
Line Cluster
SPATA Control
Terminal Processor
Terminal Control
Switch Control
Signalling
Charging
MTCE
Auxiliary Call Processor
Signaling, Switch Control
Trunks & Service Ckts.
Trunk/ Service Circuit Cluster
SPATA Control
Terminal Processor
Terminal Control
Switch Control
Charging
SVC Circuit Control
MTCE
Auxiliary Database Processor
Switch Control
Translations
Resource Manager
MTCE
Digital Switch Network
Bulk Memory
M/M Devices
Control & display
Data Links
Computer Peripherals
Terminal Processor
I/O
Switch Control
Restart & Recovery
Charging, Operations
Administration
MTCE

Figure 7. ITT 1240 Implementation of Fully Distributed Control.

2. Allocating resources to calls requires status information on these resources which are controlled by a relatively large number of terminal processors.

Thus, a pool of processors is configured which handles the database functions. For reliability purposes, these are usually provided in an N+M or a standby redundancy mode. Of interest, additional processors can be connected to the network such that if one of the database (or even auxiliary call control) processors should fail, one of these spare processors could be put automatically into service, resulting in a self-healing system at this level.

Other abbreviations in Figure 7 are:

Mtce:	Maintenance
SVC :	Service
M/M :	Man/Machine Communication
I/O :	Input/Output

Consider a terminal processor and its associated call control processor, sending and receiving digital messages via the switching network, and with total access to the database functions: this is precisely the capability of the independent terminal controller, which configuration eliminates the control bottlenecks of traditional switching systems.

The implemented network is a unique design as well. It consists of a single printed circuit card type, which provides both time and space switching, and which has all the logic on the card to select both an idle channel from a given port or group of ports, and to perform the necessary maintenance and diagnostic functions required. This logic is provided per port (a single custom LSI per port) providing the capability in each time slot for whatever function is required. Thus, it is capable of setting connections on each time slot of each port simultaneously.

This current implementation of fully distributed control thus avoids all of the bottlenecks of traditional systems for ISDN, and incorporates the advanced concepts of the independent terminal controller.

6. CHARACTERISTICS OF THE RECOMMENDED ARCHITECTURE

The most significant characteristics of the current implementation, which provides the advantages for ISDN, are:

1. The terminal control elements serve an extremely small number of terminals - 128 lines, 30 trunks. Their real time occupancy for telephony is 30%; 25% for overhead, 5% for call handling.

2. The quantity of auxiliary control elements is engineered to provide a given grade of service, regardless of exchange size or calling rate. That these control elements use ordinary network terminals allows their expansion almost without limit.

3. The network is a unique design with control over the speech/data paths, and allows simultaneous control events over all paths.

Thus, this design is completely open-ended in terms of its call handling control capacity, lending itself more readily to the ISDN world than conventional designs. For example, if the normal evolution of features reduces the terminal capacity of a conventional system by one half in 15 years, and the ISDN features also reduce it by one half or more, a 40K line system today should not be engineered for more than 10K lines, for that could be its capacity in 15 years if ISDN becomes a fact (which is almost a certainty before 15 years).

With the recommended architecture, you can merely add more processing capacity without any real regard for capacity limitations. You can install, for example, a 40K line exchange, increase its processing capacity by the 5% per year, and when ISDN features are required, add the control capacity for that as well, all the while maintaining the 40K lines capacity.

To illustrate, we calculated for a country with a very high calling rate for telephony the maximum sized exchange that would use up all the network capacity. It turned out to require 1.5 million BHCA, which this structure can handle. On top of this, we could still add processors to handle ISDN requirements.

These numbers are given as examples only. The point is, all conventional architectures have capacity limitations whereas the fully distributed control structure is open-ended. A note of caution: some suppliers are claiming not only distributed control but fully distributed control. ITT has incorporated all the characteristics derived from the analysis of ISDN requirements in its ITT 1240 Digital Switching System; to the author's knowledge no other supplier has fully eliminated the capacity restrictions of CPU systems nor provided the self-controlling network that supports it.

7. OTHER ADVANTAGES

The fully distributed architecture of the ITT 1240 (Figure 8) provides significant advantages to the administration beyond its unique adaptability for ISDN. It is beyond the scope of this paper to consider these in detail, but a brief listing of some of them seems appropriate:

- Many times more fault tolerant.
- Processor capacity always matched to exchange requirements - no large getting started cost.
- Smooth economic growth over total range.
- Simplifies network planning and provides for economies in outside plant.
- Quality of service constant over all exchange sizes.
- Smaller number of card types, simplifying training, maintenance, sparing.
- Open-ended flexibility for new features/technology.

8. SUMMARY

In addition to the already increasing processing needs in telephone exchanges, the switching requirements for ISDN can be expected to increase the calling rate per Erlang, compared to telephony, by several orders of magnitude or more. Traditionally designed systems with central processing and multi-central processing units, and with TST switching networks, have numerous bottlenecks which will limit their application in the ISDN arena. Even at the high capacities suppliers are quoting today, they still have a finite upper limit which restricts their flexibility to adapt to changing requirements.

An architecture combining fully distributed control with a unique, unlimited-attempt digital switching network has been described which completely avoids all the bottlenecks of traditional systems. Its open-ended control structure uniquely positions it to adapt to the rapidly changing requirements of the ISDN world.

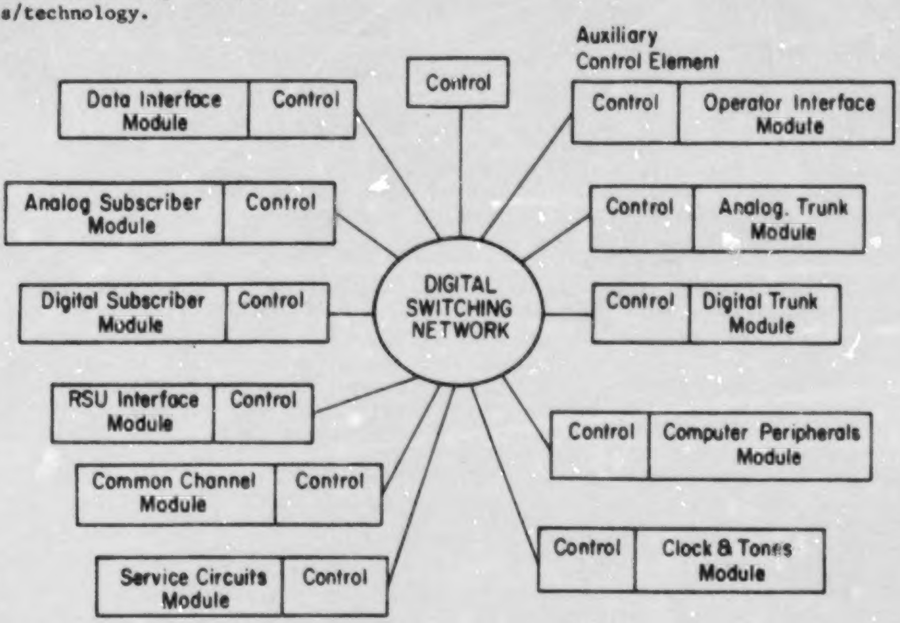
Auxiliary Control Element
Control
Data Interface Module
Control
Control
Operator Interface Module
Analog Subscriber Module
Control
Control
Analog. Trunk Module
DIGITAL SWITCHING NETWORK
Digital Subscriber Module
Control
Control
Digital Trunk Module
RSU Interface Module
Control
Control
Computer Peripherals Module
Common Channel Module
Control
Control
Clock & Tones Module
Service Circuits Module
Control

Figure 8.

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ABOUT THE AUTHOR

K. F. Giesken was born in 1936 in Glandorf, Ohio. After serving as an electronic technician in the US Navy, he gained a BSEE in 1962 from Ohio Northern University, and an MSEE in 1965 from Ohio State University. In 1962 he joined Bell Telephone Laboratories where he participated in the development of No. 5 Crossbar, and was instrumental in the design of No. 3 ESS. In 1973, he joined the ITT Headquarters Technical Group, and supported various projects around the world. From 1976 to 1981, he was closely associated with the ITT 1240 project in a number of roles, and is coholder of the basic network patent "A Continuous Expandable Network" for the ITT 1240. Since 1982, Mr. Giesken has been Director Technical Support for the Asia Pacific and Latin American countries.

ISDN - DEVELOPMENTS IN ASIA

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GENERAL

In recent years technology has advanced with ever increasing rapidity and we have progressed from electro-mechanical step by step to analogue Stored Programme Control to digital systems in a very short time. The general concensus of world opinion is that future telecommunications development is clearly evolving towards an Information Network System that will be based on the establishment of an Integrated Services Digital Network. It is also recognised by many Administrations that this target ISDN will be best achieved by the initial establishment of a digital telephone network, including provision of basic data (non-voice) services. Asian Administrations are moving in this general direction.

ASIA PACIFIC SEMINAR ON NETWORK DIGITALISATION

In March 1983 Hong Kong hosted a Seminar on "Network Digitalisation in the Asia-Pacific Region" on behalf of the Asia-Pacific Telecommunity. Conclusions and recommendations of the Seminar were as follows:-

a) Conclusions

- it proved to be an excellent forum for discussion and a wide range of issues involved in preparing a telephone network for IDN were identified.
- it focussed attention on the fact that most member countries had adopted some form of digital transmission media in recent years, and that each country was aiming to introduce digital switching to complement this; thus, the IDN would evolve.
- it identified common areas of concern in respect of staff training and manpower considerations as a result of transfer from labour intensive analogue techniques to digital.
- it also considered the application of digital technology in a telephone network and studied the different options of introduction viz, overlay, island or pragmatic configuration. The different applications were considered in respect of introduction both in urban as well as rural areas.
- it further considered the particular requirements for international interconnection of IDN.

b) Recommendations

- there would be regional cooperation in dissemination of experience and information on the introduction of digital facilities.
- the larger (experienced) Administrations would assist others, in addition to equipment suppliers, in providing training for the lesser-developed nations.
- seminars would be organised via the APT within the region to aid information exchange and training.

The above gives a broad appreciation of the approach being taken within the Asia-Pacific Region to the ever increasingly important subject of digitalisation of local and international telephone networks.

Many of the Administrations in the Asia-Pacific area can be considered as "lesser developed nations" in telecommunications terms. They all recognise the merits of digital technology and are keen to join the march towards introduction of an ISDN, however, they cannot justify discarding existing serviceable analogue equipment and their progress towards a total digital capability must inevitably be much slower than that of "developed nations".

There are two distinct areas of digital development necessary for global adoption of the ISDN concept. These are the provision of:-

(i) local (national) and

(ii) international gateway interconnection facilities.

Each of these has its own separate sub-divisions of switching and transmissions.

HONG KONG

Hong Kong occupies a vital strategic position in the Asian Pacific area.

Hong Kong's Digital Development

Hong Kong is seen as one of the more developed nations in the Asia-Pacific region and its digital development is described here in rather more detail as an indication of this Region's interest in the subject of digitalisation and the introduction of the I.S.D.N.

[I would hasten to add that both Japan and Australia are usually well represented at this conference and I would not presume in this paper to imply that Hong Kong is ahead of those two countries with its ISDN development; because of the size and scope of their domestic networks time would not permit an adequate coverage of their territories.]

The Local Network

The Hong Kong Network has over 1.6 million working exchange lines and expects to reach 2 million by the end of this decade. The problems faced in meeting this high growth in an already densely developed network can be summarised as follows:-

- a number of exchanges were reaching capacity
- high cost of real estate (technical buildings)
- construction of new towns
- a burgeoning trade and financial centres need for news and data services
- a volatile economy which needs a flexible network
- escalating future costs for analogue equipment

Switching

In the late 1970's Hong Kong undertook strategic network studies to determine the viability of digital switching in the local network; from these studies it was concluded that its introduction was a natural evolution from the extensive PCM junction system that had been progressively installed since the mid 1960's. After an extensive evaluation that covered economical, commercial and technical aspects, a contract was awarded in April 1981 to Fujitsu Ltd Japan for local and tandem switching centres using the Fetex-150 Digital Switching System.

To date Hong Kong has installed one local and three tandem exchanges; all are performing excellently. It is confidently expected that continuation of this digitalisation programme will provide the following benefits:-

- Saving in equipment space utilisation
- Combined digital transmission with switching resulting in an effective and low cost network
- Provision for high bit rate data and other new services
- Flexibility in design
- Price reduction compared with present cost
- Future use of common channel signalling

Transmission

Transmission planning in a conventional analogue network is usually a compromise between the 'preferred' transmission performance (as defined by CCITT) and what is economically feasible.

IDN's have different transmission properties when compared with analogue networks, the most significant being that the level, frequency response and signal/noise ratio are virtually independent of the number of switching points or distance; in this respect the IDN can be considered as lossless.

However, digital switches introduce new transmission impairments and while it is recognised that a fully integrated digital network will significantly improve speech transmission performance such a network will take many years to evolve.

In the meantime, the transitional mixed analogue/digital network will introduce its own particular problems and careful planning is required to ensure that the transmission performance is not degraded as digital switching and transmission systems are gradually introduced into the existing analogue network.

The digital transmission plan proposed for Hong Kong is intended to:-

- eliminate junction transmission variations
- reduce local loop transmission variations
- control speech power transmitted on international circuits

The rules adopted in Hong Kong for inteconnecting digital exchanges are as follows:-

(a) Digital Exchange to Digital Exchange

- to be connected by digital transmission systems

(b) Digital Exchange to Analogue Exchange

- to be connected by PCM. Temporary connection by physical circuits will be allowed prior to conversion to PCM however this could involve a transmission penalty and each case will be considered individually.

Currently Hong Kong is operating an extensive PCM network throughout the territory and there are over 900 system ends in operation representing well over 50% of all working junctions. The interconnecting links between local and international facilities are virtually all PCM.

Hong Kong has also pursued a policy of introducing high capacity fibre optic cable systems and now has over 5 million metres of optical fibre in a total cable length network of 270 kilometres linking 24 major switching centres and 9 radio stations (mobile services).

Hong Kong International Gateway Digital Facilities

In most countries there has been, in the last decade, a phenomenal growth in international traffic, this growth often far outstripping the growth in the local network; this trend has also been evident in Hong Kong.

The total outgoing international traffic has grown by over 350% between 1978 and 1983. Although the increase in international traffic in the coming years is unlikely to be quite as spectacular, it is, nevertheless forecast to grow at around 20% per annum.

In order to cope with the rapidly expanding international traffic and for various economic and operation reasons Hong Kong is in the process of introducing digital International Switching Centres (ITSC's).

The introduction of digital ITSC's into analogue environments provides immediate advantages to the operating administration and prepares the way for the introduction of the Integrated Service Digital Network (ISDN) with the resulting benefit to the customer of more extensive facilities in the long term.

The administration introducing the digital ITSC gains the following advantages regardless of whether the interworking environment is analogue or digital;

- reduced floor space requirements (approximately 10:1 against crossbar switching area)
- high reliability with reduced maintenance
- full availability, ie virtually non-blocking switches

More significantly, when digital switching and transmission are combined to form the integrated Digital Network (IDN) the following will result:-

- cheaper termination costs
- improved overall network economy
- improved transmission performance
- subscriber network cost reduction
- common channel signalling (eg CCITT No 7) easily accommodated facilitating progression to the ISDN
- improved network management - dynamic control of circuit usage.
- facilities can be enhanced or provided more economically, eg signalling and echo control etc will need to match the reliability and security of the digital ITSC.

Summary of Hong Kong's Position

Hong Kong has adopted a dual gateway ITSC philosophy to provide diversity of international facilities and to give improved security of access for customers. Both ITSC's are of the Stored Programme Control type, one an Ericsson ARE and the other an Ericsson AXE and are linked via two fibre optic cables. Hong Kong has extensive network facilities with direct connections to over 50 destinations worldwide plus over 30 destinations in China. At present CCITT 6 signalling is used both within the Asia-Pacific Region and to the other countries, among them: Australia, Japan, Singapore, United Kingdom and the U.S.A.

It is Hong King's view that digitalisation is essential in both international and national telephony to ensure the integration of voice and other digital new services over the international network.

The Status of Other Asia Pacific Administrations

SINGAPORE

Experience in digital technology began in 1968 with limited PCM experiments; by August 1982, 1400 systems had been installed and this should have doubled by end 1984. Planning for digital switching began in 1978 and like Hong Kong the Fujitsu Fetex-150 system was chosen, installation commenced in 1982.

In August 1984 the Singapore Government awarded a US$4 million contract for 48 Northern Telcom SL-1 digital PABX's for installation in its domestic network.

The Telecommunications Authority of Singapore (TAS) announced in the Financial Times of 27th November 1984 that it was embarking on a Sing$3.3 billion (US$1.54 billion) 5-year capital expenditure plan.

- By the end of 1987 all of Singapore's 25 telephone exchanges will be linked by fibre-optic cable.
- It is of interest to note that 650 (5%) of the 13,000 personnel that TAS employs is engaged on the planning of the digital network and its future integrated services.

MALAYSIA

On the whole Malaysia's present telecommunications network is still analogue and digitalization efforts, in the local, junction, and trunk sections, will take some time to complete. However, the Malaysian Administration, in October 1984 awarded a £155 million (US$194 million) turnkey contract for the supply and installation of a composite digital microwave and fibreoptic backbone transmission network - the project is scheduled for completion during 1987.

The total value of contracts placed to date to replace existing analogue equipment exceeds US$860 million, a large proportion of this being awarded to NEC of Japan.

As an indication of progress the following figures show the transmission systems used/planned for domestic trunk circuits.

Systems	As at End 1980	Planned for End 1980
Physical Pair	62.5%	33.5%
FDM	35.5%	30.0%
Digital	2.0%	36.5%

TAIWAN

In 1981 Taiwan launched a 10-year telecommunications development plan.

In June 1981 a No.4 ESS digital toll switch was installed in Taipei - this was planned to be the hub of the main network with a second similar switch planned for installation in Kaohsiung by 1986.

Current budgets call for the spending of some US$5.25 billion on network digitisation during the course of the next 5 years.

Looking ahead, by 1995 they expect to have installed between 4 and 6 million new end-user digital lines - accounting for just over 50% of the system capacity.

Digital microwave systems are being installed across certain parts of the country and to some of Taiwan's off-shore islands; fibre-optic cables are being installed, where appropriate, to meet ever-increasing demand and the goal toward complete network digitalisation.

THAILAND

The Telephone Organisation of Thailand (TOT) is the domestic carrier whilst all international facilities are provided by the Communications Authority of Thailand (CAT).

There is some movement to replace existing crossbar exchanges by SPC exchanges and for the first time IDD will be available from January 1985.

It is generally expected that the domestic network will be privatised and until this is put into effect any further plans to 'go digital' or move towards ISDN appear to be remote or "deferred".

SOUTH KOREA

A number of digital installations are in-hand or planned, but much of the incentive in this field is for the 1988 Olympics and an earlier major event the 1986 Asian Games. Although these modern installations will meet a specific need they will be available for integration into the local digital network as it evolves.

South Korea is now in the middle if its US$830 5-year plan to modernise its domestic voice and data networks.

The plans include ATT's 4 ESS and 5 ESS together with fibreoptic trunks which are due to be operational for the Olympics.

As at May, 1984 34% of long distance trunk circuits were digital, this is expected to rise to 92% by 1991 by which time some 50% will be via fibreoptics.

INDONESIA

The PTT (Perumtel) plans to invest some 60 million Guilders on expansion of its 31 Philips PRX electronic exchanges during 1984/85. ISDN plans have not yet been specifically mentioned by Indonesia.

PHILIPPINES

There are currently 62 Telco's, 7 domestic record carriers, 4 IRC's, 1 domestic satellite carrier and several franchised radio carriers.

A strategic national plan was issued in 1981 which includes a backbone national transmission network, this being fully digital (both voice and data).

Aspects of these installations are still in progress but many of the projects appear to have been frozen during 1984 in light of political and economic uncertainties.

Conclusion

The concept of an integrated services digital network (ISDN) has become a major driving force behind telecommunications network evolution among Administrations and in a variety of discussion forums around the world.

Each Administrations has to plan for an ISDN which will provide a basic universal telephone service and support an ever increasing range of customer needs. It is vital to remember that these customer needs in urban and rural areas are very much different and that these differences are further exaggerated when comparing one Administration/Region with another, this is particularly so in the Asian Region.

Existing analogue networks were primarily designed for voice traffic, since voice is the largest component of telecommunications traffic and will no doubt conitnue to be so for a number of years to come.

Although the above constraints presents foridable challenges the widespread adoption of digital technology indicates that progressive digitalisation of the network is occurring and that an ISDN will evolve. In order that all countries can obtain maximum benefit from this ultimate position there must be continuing international consultation and agreement on standards and services; both within CCITT and at special Regional sessions.

We in Hong Kong are confident that with the good will and expertise that exists both worldwide and regionally meaningful deliberations and exchange of ideas will take place at all levels. This will lead in turn to recommendations on various aspects of network digitalisation and evolution towards ISDN including the most economical strategy to adopt during the co-existence of analogue and digital networks.

THERE'S AN ISDN IN YOUR TELECOMMUNICATIONS FUTURE

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Abstract

Services Digital Networks ("ISDNs") accord users one versatile medium to transmit and process any type of intelligence. The convenience of one "transparent" conduit requires major changes in the policy, industry structure, economics and regulation of telecommunications and information processing. For ISDN to become internationally ubiquitous and interconnected with domestic systems, nations must accommodate new technological imperatives, coordinate systems, and plan universal operating formats while no doubt promoting national philosophies and products. For its part, the Federal Communications Commission must adapt domestically based policies and rules for the international arena without abandoning its advocacy for ISDN flexibility and open access.

Introduction

Integrated Services Digital Networks ("ISDN") promise to merge previously disparate telecommunications and information processing services into a diverse menu of offerings over one very versatile line. The marketplace for such services heretofore has operated on the premise that no one entity could configure its network to accommodate all user needs. Technological, marketing and regulatory limitations have structured an industry in terms of what subset of services an enterprise offers. Regulated common carriers provide telecommunications services primarily divided into voice and non-voice (textual, video, facsimile) categories. Unregulated information service providers lease lines from common carriers to provide a variety of data processing services. With the onset of a flexible and ubiquitous network capable of transmitting any communications or data processing service, market divisions and regulatory policies break down.

In late summer, 1983, ISDN reached the FCC's public agenda. A concept, which telecommunications planners had bandied about for years, ISDN finally entered the Commission's lexicon as:

> a network which is designed and constructed to provide a wide range of telecommunications and information services and to transport electrical signals in digital, rather than analog form.(1)

ISDN becomes a matter for regulatory agency review because of its far reaching policy, industrial structure and regulatory consequences. Like no other technological development, ISDN threatens to require major modifications in the manner by which consumers access and use telecommunications and information services. A singular worldwide ISDN can furnish the underlying transmission pipeline for all services that assorted carriers now provide over discrete networks. Customers need not look to one carrier for international telephone service and another for data and yet another for video teleconferencing, telex, or facsimile transmissions.

ISDN renders the telecommunications line a "transparent" conduit and building block for any service. The transmission path merely fosters the exchange of pure binary digital sequences without regard to the content of the data. The telecommunications medium becomes a malleable pipeline for the carriage of electrical pulses with variables like bit speed, code, format and protocols(2) determining what will constitute the final makeup of the signal.

Once ISDN becomes as internationally ubiquitous as the numerous individual services and carrier networks we currently have, then all technologically based restrictions on what a particular carrier can offer become moot. The International Record Carriers ("IRC"), which currently provide mainly private line, telegraph and telex service, can easily program their networks or tap into a shared ISDN to handle voice, video, high speed data and other types of traffic. Likewise, the AT&T network, now primarily geared for switched voice telephone service, can be extended to carry data signals of wider bandwidths and various transmission speeds. Technology will sanction no protected market niches because one carrier's digital network can furnish all services that other carriers have provided exclusively. However the end to exclusivity requires all carriers to interconnect their systems and also to agree on universal technical and operational standards.

While the FCC has conscientiously sought to eliminate arbitrary, anachronistic or disfunctional international service limitations,(3) it will have to complete this mammoth deregulatory campaign by the onset of digital networks. Until that time, particular subsets of carriers and customers will decry that they cannot serve particular markets merely because other carriers have carved protected niches with the acquiesence and sometime active support of the FCC. Currently, public switched carrier networks for telephone or record services do not lend themselves to high speed data services. If customers desire additional discrete services, they must deal with a subset of carriers who have opted to augment their conventional telephone or telex offerings. In the alternative, high speed data users can acquire their own lines, often provided over a different quasi-public network or as a private closed circuit. Much of the Commission's international telecommunications policy until the middle 1970's was predicated on how carriers should concentrate on serving market segments, originally as a function of the technology they employed, but later more like an anachronistic market division process.

The digitization of signal carriage means that one network can serve most or all customer needs. Who will own the network, how network interconnection will be made, and what built-in network functions and intelligence will be permitted become a few of the questions for resolution. The FCC, National Telecommunications and Information Administration (NTIA) and State Department and their foreign counterparts, as well as various international policy making and standards setting bodies have begun the task of establishing policy solutions and functional definitions. The stakes are extremely high and filled with pratfalls for the current telecommunications carrier or information processor who fails to plan for fundamentally changing circumstances. Likewise, consumers will need instruction and guidance in planning how to optimize their line usage plans to meet particular service needs.

ISDN Development and Policy Formation

The development of ISDN represents the culmination of an ongoing move away from telecommunications networks based on the carriage of voice (analog) traffic to a versatile digital format. We now stand at the midpoint of this evolution with the existence of two sets of bifurcated systems:

(1) networks divided into analog or digital transmission modes;

(2) networks separated into ubiquitous, switched or private, unswitched categories.

With the onset of digital networks, financial and logistical pressure may force users off their private networks and onto a substantially flexible, but consolidated switched ISDN system. Until such networks become ubiquitous, carriers and customers will need to install assorted devices to convert analog signals to digital carriage and vice versa. Likewise, the lack of universally applied technical and operating standards often means that carriers and customers in different countries will need to install costly devices to perform conversions in operational formats or protocols to link lines designed to serve an individual nation's domestic telecommunications and information processing needs. Only in time will "the trend toward digitalization ... [become universal and thereby] reduce costs, increase service quality and provide new services to the user."(4)

Getting from a telecommunications/information processing marketplace, rife with different technical standards and operational formats, to a universal digital system will take coordinated international planning and compromise. "This uniformity would permit national ISDNs to interconnect and form a worldwide system or systems, and would promote ubiquity of technical equipment used therein."(5) However, a seemingly laudable quest for standardization raises serious policy questions that affect service providers, equipment manufacturers, users and the international marketplace attractiveness of a particular country's set of services and equipment. The establishment and promulgation of uniform ISDN standard equipment interconnection interfaces, protocols and rules will take years of consultation, participation and planning among nations primarily in such forums as the International Telecommunications Union(6) and the International Organization of Standardization.(7) How robust and competitive U.S. service providers and equipment manufacturers can be domestically and internationally will depend significantly on what international forums decide and the success of U.S. sponsored policies and initiatives.

The concentration of resources and investment into one ISDN predictably will create the incentive for foreign telecommunications providers, Post, Telegraph and Telephone ("PTT") administrations to consolidate their offerings and options available to users. Such a move may substantially restrict the ability of some large volume users to continue engineering private international networks tailored for specific needs, e.g., secure, encrypted military data networks, high volume banking networks, and global airline reservation systems. While ISDN may adequately satisfy the needs of large volume users, it will likely be priced on a usage sensitive basis like existing public switched networks, i.e., one pays as a function of time or volume of usage. Private line users, who pay a flat rate for bulk transmission capacity, will not appreciate massive rate hikes caused by a forced migration to ISDNs even if the line promises greater transparency and adequate flexibility.

ISDN and FCC Service Categories

When ISDN becomes a reality, previous domestically based FCC service definitions will no longer functionally identify submarkets, heretofore subject to vastly different regulatory treatment and levels of competitive pressures. For some time now, the FCC has attempted to draw workable service boundaries between "basic"(8) carrier-provided telecommunications and unregulated "enhanced"(9) information processing services. The Commission established this dichotomy to foster a distinction between what regulated common carriers can provide exclusively, and what others, including carrier subsidiaries, can provide on an unregulated basis, having acquired the transmission capacity from a carrier pursuant to tariff.

Service segmentation fostered by the FCC's Second Computer Inquiry(10) cannot function internationally given the likelihood that PTTs will seek to incorporate "enhanced" characteristics within the ISDN system. In the United States, the Commission expects such enhanced services to be competitively provided in an unregulated environment fully separated from the conveyancing of underlying basic transmission capacity. Foreign countries have not embraced the need to separate telecommunications capacity from line enhancements. PTTs will invest substantially in updating their existing networks to ISDNs, and will seek to maintain their monopoly stronghold over any service that arguably fits within the rubric of PTT service. Because basic and enhanced services can coexist over the same transmission pipeline, any restriction on who can provide a particular subset of the ISDN traffic volume addresses marketplace, regulatory, semantic and policy goals rather than technological limitations.

PTTs consider most enhanced services as simple extensions of existing services and new profit centers legitimately retained exclusively for carriage over their telecommunications network. Conversely, the FCC contemplates a fully functional dichotomy between carrier-provided regulated basic services and unregulated enhanced services.

A fundamental deviation in interests and philosophy over ISDNs may pit the United States against other nations. The PTT consolidation of any new service transportable over ISDN conflicts with U.S. policies favoring a plethora of carriers and services subject only to that degree of regulatory oversight necessary to protect the public interest. The juxtaposition of national interests may temper or force modifications to the international application of a U.S. philosphy supporting substantially unregulated marketplace competition.

The capacity of ISDN to handle many types of information processing applications may bring aspects of data processing under the relm of the PTT. With the attachment of equipment at both ends of the line and with application of protocols designed to accommodate data transmission, the PTT in essence furnishes an intelligent information services transmission network. Expanding the "wingspan" of a government agency or franchisee conflicts with a U.S. policy favoring private enterprise and restricted governmental intrusion. The FCC has taken great efforts to free data processing from any regulation by concentrating on how the telecommunications building blocks are procured and tariffed, rather than who provides a particular service.

Given the U.S. goal to confer maximum sovereignty and flexibility to the telecommunications user, foreign PTT efforts to incorporate new data processing services conflicts with the U.S. deregulatory campaign. As a result:

> in the U.S., competitive market forces could result in some deviation from ... [international ISDN] standards. If, in the U.S., customer premises equipment were to operate at standards which were technically incompatible with or inferior to CCITT adopted standards, it could result in traffic being restricted to domestic termination points, unless an additional layer of hardware and/or software could be added.(11)

Unless the U.S. succeeds in having international forums adopt a flexible approach whereby customers and not carriers alone can configure the ISDN, three outcomes injurious to U.S. users, service providers and equipment suppliers may result:

(1) enhanced service providers, permitted by the U.S. to operate without regulation and FCC authorization, must acquire foreign operational privileges and may experience difficulty in convincing PTTs that they are as reliable and legitimate as regulated basic services common carriers, who will similarly operate over the ISDN;

(2) U.S. manufactured equipment, designed to furnish enhancements to basic transmission capacity, may duplicate functions built into the ISDN thereby rendering the U.S. offerings unnecessary or inadequate; and

(3) any U.S. move to favor native customers, carriers or manufacturers in the public interest may fail to secure international acceptance and compatability with international ISDN standards.

Should the FCC apply an unmodified Second Computer Inquiry policy in an international ISDN context, it may close out basic services providers from attractive ISDN opportunities. The Commission may also reduce the apparent legitimacy and attractiveness of unregulated and unsanctioned enhanced services providers. Conventional carriers may have to create separate subsidiaries to buy basic capacity pursuant to tariff whereupon the subsidiary will add enhancements, some of which international ISDNs will already have incorporated. Under a strict application of the *Second Computer Inquiry*, the FCC will look for ISDNs that do not incorporate features deemed "enhanced." Otherwise, international ISDNs will possibly differ substantially from domestic U.S. networks. The Commission or other U.S. international policy advocates would then have to promote international ISDNs that can isolate or eliminate such enhancements for U.S. traffic much like the way FM stereo receivers can carry monaural signals without impairment.

Even at the incipiency of ISDN, domestic-based regulatory dilemmas and marketplace philosophies may generate confusion, additional costs or barriers to entry. ISDN, as an evolutionary concept in telecommunications and information processing transport, should not become embroiled in semantic line drawing, particularly if specific regulatory adjustments to accommodate characteristics of the international marketplace are possible without contaminating the domestic market benefits accrued from the policies expressed in the *Second Computer Inquiry*.

FCC Report on ISDN

Judging from its First Report on ISDN(12) the FCC will continue attempting to finesse a position advocating international accommodation of domestically minded Commission policies. The FCC must do this without intruding on the turf of international forums or other U.S. government agencies, contaminating functional domestic policies with internationally-minded modifications, or interfering with technical and marketplace-based ISDN design and planning. The Commission expressly notes that it views its role as promoting competition through multivendor, maximally flexible, and easily accessible ISDNs consistent with the policies in the *Second Computer Inquiry*.(13) However, it acknowledges the duty to consider international comity,(14) the international policy making process wherein the Department of State should spearhead U.S. representation(15) and the fact that technological innovations can be incorporated and packaged in manifold configurations with different lines of demarcation between carrier and customer provided equipment and network enhancements.

The FCC retains a policy interest "because much of the analysis of the ISDN concept has involved classification of communications and information-handling functions"(16) which may conflict with the *Second Computer Inquiry*. The Commission also bears a "potential regulatory interest since ...FCC certification may at some point be required...[for] the construction and acquisition of many facilities by...carriers to implement the ISDN concept."(17)

To the extent that international telecommunications and information service planning and dissemination conflicts with Commission philosophy, policy or zeitguiest, it indicates some willingness, short of outright advocacy, to disseminate information on ISDN and "to provide a forum in which [it] ... may be sensitized to ISDN ramifications which might not be readily apparent so that through our participation in and monitoring of ISDN developments we might better perform our role."(18)

In the absence of better, more cohesive, and expert participation by NTIA or the State Department, the Commission appears willing to fill a void by promoting:

- maximum flexibility in the internationally adopted numbering/addressing specifications, i.e., how carrier and service provider networks are accessed by dialing sequences;
- the ability of end-users to attach customer premises equipment that satisfy particular needs and obviate the need for the network proper to provide similar but not always necessary or maximally efficient functions;
- compatibility of the *Second Computer Inquiry* basic/enhanced services dichotomy with different international service definitions and a modus operandi that will not bifurcate an ISDN network into regulated basic services and unregulated enhanced services;
- the ability of carriers to provide certain value adding network functions without deeming them enhanced services;
- international interconnection, policies service definitions, and operator procedures that favor multiple and competitive carrier services;
- retention of dedicated private line service leasing in the face of mounting foreign pressure to favor public switched "virtual circuits," -- non-dedicated, but readily available facilities.

ISDN Message Addressing and Routing

The U.S. stands virtually alone in actively promoting a multiplicity of telecommunications service providers. Whenever end-users have a choice of offerings and carriers, a nondiscriminatory "equal access" message-routing and numbering framework is necessary. Currently, U.S. local exchange carriers are reconfiguring their networks to ensure that new long distance telephone service carriers achieve parity with the dialing regimen currently enjoyed by AT&T. The U.S. has also employed an international numbering scheme for data networks to foster a multiple carrier/service provider environment.(19) An analogous access system for ISDN will ensure that a pro-competitive environment thrives in the U.S. even if other nations opt for sole PTT provision of ISDN service. The ISDN plans currently call for accommodation of multiple vendor addresses.

CPE Functions

The Commission has deregulated customer premises equipment ("CPE")(20) and seeks to reduce carrier provided functions to that which is essential for customers, and not something optional or easily provided by user-attached equipment. Similarly an equipment registration program specifies "only technical limitations which prevent 'harm' and not one which addresses the efficiency or utility of the connection." (21) ISDN plans, however, may impose mandatory CPE functions that need not be universally used or provided solely by the ISDN carrier. Such plans also may deem as integral parts of the network certain functions that the U.S. has considered severable and available from customer attached CPE.

To the extent that optional functions are mandated for CPE accessing international ISDNs, U.S. equipment manufacturers and domestic ISDN carriers may be forced to incorporate such functions or face incompatibility with international networks. This incentive to comply with international conventions may result in higher CPE and network costs for consumers. Likewise, FCC decisions which legitimize certain CPE functions that international forums subsequently deem as functional carrier network features, create an imbalance between the U.S. and the rest of the world. It remains to be seen if the Commission and other interested U.S. parties will have to capitulate and comply with the apparent international consensus or whether a domestic-international equipment policy dichotomy will evolve.

ISDN Compatibility With The Second Computer Inquiry

An underlying goal of particular interest to the FCC is the development of an international ISDN policy that accommodates the Commission's *Second Computer Inquiry* service definitions and regulatory scheme. International ISDN forums have opted for different service titles and tend to view new technologies in terms of how telecommunications authorities or government bodies seek to incorporate such innovations. CCITT planning documents first classified ISDN into "bearer" and "telecommunications" services with a later modification that established one overall ISDN service category with two subcategories, "bearer" services and "teleservices."(22) Bearer services, for the most part, will fit into the *Second Computer Inquiry*'s basic services category with teleservices falling into the enhanced classification.

CCITT definitions are mere recommendations and "no administration is foreclosed from including (or authorizing the inclusion of) any 'teleservices' and other functions in its telecommunications facilities and offering, should it so desire."(23) However, such recommendations have routinely been incorporated as international standards and, as such, the Commission will find its dichotomy out of line with prevailing practice and policy. No matter how laudable the Commission's quest to expand the set of unregulated or non-common carrier/PTT offerings, it will find it necessary to make ad hoc modifications or international qualifications to the *Second Computer Inquiry*.

Protocol Conversions

Even in the domestic context, the Commission already has acknowledged that certain enhanced functions ought to be available from primarily basic service carriers. As the ISDN definitions become fine tuned, there may be an even greater impetus to shift the basic/enhanced line of demarcation so that U.S. carriers might perform the same functions that their foreign counterparts routinely incorporate into their networks.

In the Commissions *Protocol Decision*,(24) the Commission authorized basic services carriers to make internal conversions while transmitting signals so long as "reproduction at the far end of a connection of the electrical signals" is the same as what was initially introduced into the network.(25) This concept of "transparency" means that carriers may perform certain protocol conversions or processing "intrically necessary for switched message services to be provided,"(26) e.g., alerting the network that a terminal is ready to generate or receive a call, converting an analog signal to more efficient digital transmission for part of the way to the end-user, or making a signal compatible for carriage on a network or circuit route that has yet to incorporate certain technical advancements.(27)

Thanks to recent CCITT definitional modifications, the Commission can more confidently allege that the *Second Computer Inquiry* service definitions can coexist without "violat[ing] comity by imposing United States policy on other administrations."(28) Indeed, the Commission's Protocol Decision evinces a willingness to permit common carriers to incorporate certain enhanced functions, particularly those that bolster user utility by acting on the transmitted information while ultimately returning it to its original state.

Continued Availability of Private Line Offerings

While the FCC may be able to salvage its Second Computer Inquiry definitions because ISDN plans "include sufficient flexibility to accommodate the regulatory structure of the Communications Act,"(29) the Commission and other U.S. parties may not be able to persuade foreign counterparts to retain bulk capacity private line leasing as a service option. ISDN, by its "integrated" nature, constitutes a public switched as opposed to private, dedicated service. Given the expense incurred in development of ISDNs, PTTs have the incentive to restrict the availability of user specific, dedicated line options that have been priced on a flat rate. Such a concentration of attention and resources may well frustrate or defeat specific user needs best met when users can engineer their own network with the lowest number of physical interfaces between terminals and transmission lines. A public ISDN is apt to represent a functional compromise favoring ubiquitousness over specific customer-tailored needs. Performance, flexibility, security and economic characteristics of an ISDN may not match the levels even currently attainable through large private user networks.

Several large volume or specialized network users vigorously argued that the Commission and other U.S. government agencies should push for the continued availability of private line service options. Commentators objected even to an ISDN system that can guarantee particular customers a specific set of circuits available on a 24 hour demand, but not dedicated, basis. Such "virtual circuit" systems are considered inadequate in part due to performance factors (delays in access for data transmission and need to apply standardized protocols), but also because a switched ISDN system will likely be configured to meter service with charges commensurate with usage.

The Commission was persuaded that switched public ISDNs may dampen consumer flexibility and constrain the manner in which certain users have enjoyed line leasing on a bulk, usage insensitive basis. Notwithstanding the claims of U.S. carriers that demand basis metered circuits may adequately serve subscriber needs, the Commission sided with users. The Commission held that its "Computer II unbundling principle would best be served by the continued availability of dedicated private line services notwithstanding the emergence of packet-switched and circuit-switched ISDN alternatives."(30)

Conclusion

The wishes of the FCC and users cannot completely prevail over carriers, PTTs and preliminary CCITT edicts. Indeed the Commission's policies face structural and philosophical barriers at home. Because the FCC, NTIA and the State Department share policy formation and representation duties, disparate views, constituencies and incentives will temper any final U.S. consensus. Similarly, the Commission's fielty to marketplace resource allocation and the ultimate survival of more efficient system alternatives necessitates an acknowledgment that "it is not the function of this Commission [or other U.S. agencies] to plan or to design carriers' and others' ISDNs."(30) Nevertheless, the Commission evidences some willingness to press for its pro-competitive telecommunications policies, not only because of its philosophical convictions but also because "technical and other judgments involved in ISDN planning can and do raise policy issues...."(32)

The Commission at some point will review the applications of new and existing carriers. It must resolve such matters as carrier-to-carrier and user-to-carrier interconnections and questions of how domestic policies jibe with international standards. Without becoming an appellate body or arbitrator of non-policy or design issues, the Commission will likely pursue its "institutional interest in the ISDN planning process"(30) so that subsequent regulatory responses will be consistent with prevailing philosophy and policy.

Given that most nations will favor a single ISDN owner/operator, U.S. policy making bodies will likely experience difficulty in exporting a domestic policy favoring a multiplicity of carriers and service providers. Future generations of telecommunications and information processing networks depend on efficient and flexible planning and advocacy today.

FOOTNOTES

(1) Integrated Services Digital Networks (ISDN), Notice of Inquiry, GEN Docket No. 83-841, 94 F.C.C.2d 1289 (1983) [hereinafter cited as ISDN Inquiry].

(2) A protocol is a convention which allows parties to execute transactions between them by complying with an agreed upon set of rules, the protocol, which govern the transaction and make it orderly. The FCC explains that "'[p]rotocols' govern the methods used for packaging the transmitted data in quanta, the rules for controlling the flow of information, and the format of headers and trailers surrounding the transmitted information and of separate control messages." Amendment of Section 64.702 of the Commission's Rules and Regulations, (Second Computer Inquiry) Final Decision, 77 F.C.C.2d 384, 420, n. 33 on reconsideration, 84 F.C.C.2d 50 (1980), on further reconsideration, 88 F.C.C.2d 512 (1981), aff'd sub nom., Computer and Communications Industry Ass'n v. FCC, 693 F.2d 198 (D.C. Cir. 1982), cert. denied, 103 S. Ct. 2103 (1983). See also Digital Communications Protocols, 83 F.C.C.2d 318 (1980), n. 12, 24, infra.

(3) See, e.g., Frieden, International Telecommunications and the Federal Communications Commission, 21 COL. J. TRANSNAT'L L. 423 (1983).

(4) ISDN Inquiry 94 F.C.C.2d at 1291.

(5) Id.

(6) Working under the aegis of the United Nations, the International Telecommunications Union (ITU) with its numerous committees and study groups serves as the central organization for the determination and promulgation of technological and operational telecommunications standards and policies, some of which are recognized by treaties that the United States has signed. The ITU's vast purview runs the gamut from spectrum allocation and satellite orbital slot decision-making and registration, to the determination of administrative rules, practices and formats for the provision of telecommunications services. For a concise guide to the plethora of international policy-making forums and their functions, see A. RUTKOWSKI, UNITED STATES POLICY MAKING FOR THE PUBLIC INTERNATIONAL FORUMS ON COMMUNICATION (1981) (New York Law School Communications Media Center) and Gregg, Capitalizing on National Self-Interest: The Management of International Telecommunication Conflict by the International Telecommunication Union, 45 Law & Contemp. Probs. 37 (1982).

(7) This independent non-treaty organization comprised of representatives from 89 national standards bodies develops and promulgates international standards and has prepared a model for "open systems interconnection" of ISDNs. See ISDN Inquiry, 94 F.C.C.2d at 1292, and Attachment IV, id. at 1313.

(8) Basic transmission service, the other category, represents "the common carrier offering of transmission capacity over a communications path that is virtually transparent in terms of its interaction with customer supplied information." Second Computer Inquiry - Final Decision, 77 F.C.C.2d at 419-20.

(9) Basic transmission service, the other category, represents "the common carrier offering of transmission capacity for the movement of information," which constitutes "a pure transmission capability over a communications path that is virtually transparent in terms of its interaction with customer supplied information." Second Computer Inquiry - Final Decision, 77 F.C.C.2d at 419-20.

(10) See n. 2, supra.

(11) ISDN Inquiry, 94 F.C.C.2d at 1303.

(12) Integrated Services Digital Networks (ISDN), GEN Docket No. 83-841, First Report, FCC 84-131, Mimeo No. 34478 (released April 2, 1984) [hereinafter cited as ISDN Report].

(13) Id. at 3, Para. 3.

(14) Id. at 4, Para. 56. "[I]t is not our intent in instituting this inquiry to plan ISDN facilities".

(15) Id. at 39, Para. 66.

(16) Id. at 2-3, Para. 3.

(17) Id. at 3, Para. 4.

(18) Id. at 5, Para. 6.

(19) See International Communications Policies Governing Designation of Recognized Private Operating Agencies, Grants of IRUs in International Facilities and Assignment of Data Network Identification Codes, CC Docket No. 83-1230, 95 F.C.C. 2d 627 (1983).

(20) CPE is "terminal equipment located at a subscriber's premises which is connected with the termination of a carrier's communications channel(s) at that subscriber's premises. Second Computer Inquiry - Tentative Decision, 72 F.C.C.2d 358, 406, n. 75. For a discussion on CPE technology and difficulty in classification of services see Frieden, The Computer Inquiries: Mapping the Communications/Information Processing Terrain, 33 FED. Com. L.J. 55, 91-98 (1981).

(21) ISDN Report at 17, Para. 28.

(22) *See id*. at 21, Para. 35.

(23) *Id*. at 26, Para. 44.

(24) *Communications Protocols under Section 64.702 of the Commission's Rules and Regulations* Memorandum Opinion, Order and Statement of Principles, GEN Docket No. 80-756, 95 F.C.C.2d 584 (1983) [hereinafter cited as Protocol Statement].

(25) ISDN Report at 23, Para. 39.

(26) *Id*.; *see also* Protocol Statement, 95 F.C.C.2d at 591.

(27) *Id*. at 23-27, Paras. 39-44. Several Bell Operating Companies petitioned the FCC to grant waivers of the *Second Computer Inquiry* rules and allow, *inter alia*, internal network conversions between the CCITT X.25 protocol for user terminal interfaces and the X.75 protocol for line interconnection with packet switched networks. The Commission acknowledged the public interest value in allowing "intermediate internetworking protocol conversions," *i.e.*, procedures that maintain as essentially unchanged an end-to-end basic communications transmission while providing for internal conversions of a sort that promote compatibility of different packet switching networks more efficiently than if CPE was employed. *See Petitions for Waiver of Sec. 64.702 of the Commission's Rules and Regulations to Provide Certain Types of Protocol Conversions within Their Basic Telephone Networks*, FCC 84-561 (released Nov. 28, 1984).

(28) *Id*. at 26, Para. 44.

(29) *Id*. at 26, Para. 42.

(30) *Id*. at 37, Para. 62.

(31) *Id*. at 43, Para. 76.

(32) *Id*. at 44, Para. 79.

(33) *Id*. at 48, Para. 88.

Digital Subscriber Plant For The Papago Indian Reservation

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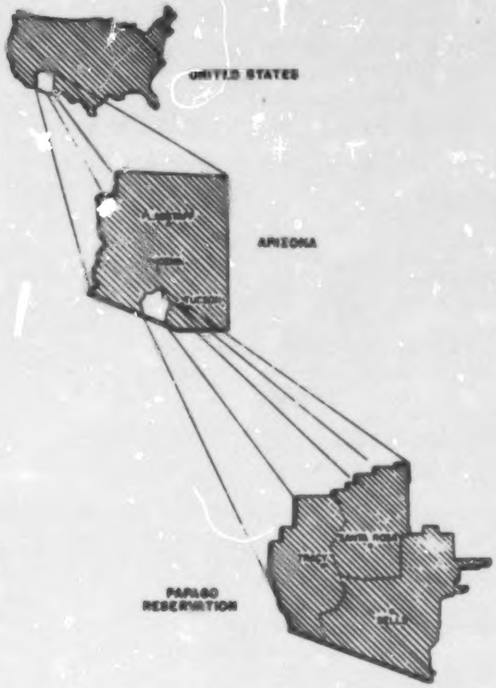
1. ABSTRACT

The Papago Indian Reservation, near Tucson, Arizona, covers 4,000 square miles. The inhabitants live in small, widely scattered villages throughout the area. A recent feasibility study by Hicks & Ragland Engineering Company has shown that telephone service can be provided at a reasonable cost to each of these villages. In this paper, the special problems of designing a telephone system for rural villages are described. The feasibility of this system was enhanced as a result of the advancements in digital communications technology. The equipment proposed and the overall design process is discussed. In addition, the estimated costs are shown.

2. INTRODUCTION

2.1 Location of the Project

The Papago Indian Reservation is located in south central Arizona. Most of the area is characteristic of the deserts in Arizona, with scattered mountains and low desert flora. This is an area of 4,000 square miles (10,360 sq. km) and home to approximately 8,500 people.



On the eastern edge of the Reservation is the Baboquivari Mountain Range. Fifty-five (55) separate communities exist on the main body of the Reservation, with the community of Sells being the largest. Tribal headquarters is located in Sells. The majority of the villages are isolated with limited access to communications facilities.

2.2 Need for Telecommunications

Basic telephone service is needed for the inhabitants to be able to communicate not only with neighboring villages but with others outside the Reservation. Numerous schools are located throughout the Reservation. The U.S. government and the Papago Tribal government need communications facilities in order to effectively carry out their functions. Due to the remoteness and isolation of many of the communities, medical facilities are limited. Good telephone service is essential for medical aid. In an isolated incident this year, after heavy rains and a flood, a community was isolated for several days until someone swam across the river and walked into town to obtain assistance. Telephone service exists to approximately 400 residents, primarily in the town of Sells, and two of the larger schools. The Papago people recognize the need for telecommunication services, and the need to update the existing antiquated facilities that are approximately 30 years old.

2.3 Philosophy of Assistance

In 1936, very little electric or telephone service existed in the rural areas of the United States of America. Congress passed what is known as the Rural Electrification Act to establish a low interest loan program to develop the necessary electric facilities in the U.S. In 1949, the Act was amended to include loans for the purpose of developing communications facilities in rural isolated areas. These loans were for a term of 35 years, at an interest rate of two percent. In recent years the interest rate has changed to be more competitive. This program is one of the most successful of any governmental program established, as the results today show that rural America, in general, has adequate electric and telephone service, with the exception of several isolated areas such as the Papago Indian Reservation.

The philosophy behind the program was one of service, at a feasible rate for the user. The decision was made that only the latest in technology would be utilized in constructing the rural telephone systems, because of the rural environment and the high cost of providing service. Rural telephone systems can least afford facilities that are incapable of providing the desired service, therefore, the REA established an Approved List of Materials so that only materials that met certain requirements could be incorporated into a system. A bid process was developed whereby materials that were listed in the Approved List of Materials would be competitively bid for pricing to assure that the lowest price for the material was obtained. Loans were based on a System Design that was prepared by an independent consulting engineer.

2.4 Summary

With the need of the Papago people for telephone service, and a loan program that was designed to help meet that need, a System Design was prepared utilizing digital switching equipment, digital microwave and digital transmission devices to support a loan request to create a telephone entity on the Papago Reservation. The system will be owned by the people that it serves.

3. SYSTEM DESIGN

3.1 Unique Problems

The population to be served by this system is mostly in small villages that are widely scattered over the area. The population density averaged over the entire area is only 2.1 persons per square mile (0.8 per sq. km), so subscribers density would be less than 0.5 per square mile (0.2 per sq. km). The area is mostly scattered mountains, however, the eastern edge is lined with a particularly high range of mountains that restricts access from the neighboring populated area of Tucson. The reservation has one major east-west paved highway and one north-south paved highway, but all other roads are generally unpaved and some are completely un-improved. This means that travel to many of the villages is restricted to good weather and very slow at best.

Present telephone service was being supplied to only thirteen percent of the inhabited establishments, most of which was in and around the town of Sells. The distant areas were not provided service of any kind.

3.2 Subscriber Forecasts

In order to determine the feasibility of a telephone system, it was necessary to project the number of subscribers who will take service. Since most of the area was deprived of service due to no existing facilities, past subscriber data was of no help in projecting the subscribers for the new system. Therefore, aerial photos were obtained and used to determine the location of establishments. These photos were compared to water and electric system records and verified through field visits to ascertain the subscriber projections. Initial service projections were held on the conservative side; but the design was made so that the system could be easily expanded should the service become widely accepted. The design was based on a five-year subscriber forecast of 1,386 subscribers. These subscribers were generally grouped in small clusters since the population was mostly in small villages.

3.3 Methodology

The outside plant design was done using a computer design program based upon the REA S.A.V.E. (Serving Area Value Engineering) technique. This program takes into account any existing plant and determines the economic tradeoffs of several designs. It also calculates the point at which electronic equipment can be used at less cost than copper cables. The program considers several types of subscriber electronics to be used.

First, the program considers the use of Subscriber Line Concentrators (SLC). This equipment can be mounted in a weatherproof cabinet and located anywhere AC power can be provided. This equipment can serve up to 250 subscribers using two carrier systems of pulse code modulation (PCM). It thus concentrates 250 customer lines into 48 conversation channels using four pairs of copper wires back to the central office, where the switching occurs. This technique was extensively used in this design due to the large distances between the small villages. This not only saved on cost of the buried cable, but it also meant better quality of service since there is essentially no loss of voice level on the PCM line.

Second, the program considers the use of Subscriber T-carrier. This is similar to the SLC except that only 48 customer lines are served over the four pairs of wire, and each customer has a dedicated channel for his use. This is slightly cheaper and proves in where there is less than 40 lines to be served. Above this, the SLC is a better choice because the additional customers can be served with no additional cost in cable or span equipment.

Third, the program considers the use of analog station carrier. This type of equipment has been available for a number of years and has been redesigned with improved electronics for more reliability. This equipment does not provide as many channels of voice, so the pair gain ratio is not as good. Thus, the equipment usually only proves economical for long runs with fewer than 10 subscribers.

This S.A.V.E. program calculates the cost of serving the customers, starting at the central office and working out, using copper pairs alone, SLC's, Subscriber T-carrier and station carriers.

The quantity of systems is calculated, plus the associated cost of housings, repeaters, electronics, AC power, cabinets, etc. These costs of serving the subscribers are recalculated at selected points along the cable route for all four methods. The program indicates the crossover point where it is more economical to serve these customers by electronics rather that paired copper cable, and which type of electronics is best to use. The results are then tempered with the engineer's judgement and experience to choose the exact placement of the electronics for best access, maximum utilization, and best potential for future growth.

3.4 System Design

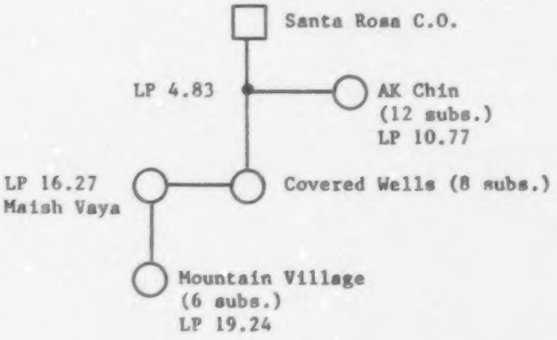
The first step in the system design was to study the whole area for population clusters and then draw dividing lines to break it into areas that could be served by separate central offices. The first site chosen was a previous location of a C.O. at the town of Sells. This included most of the previously served area and obviously the best choice for one of the the C.O.'s. A second site was chosen at the community of Santa Rosa, which is somewhat smaller, but would serve 200-300 subscribers in that area. The third site was simply chosen to be centrally located in the remaining area.

It became apparent immediately that digital electronics was going to play a major part in this design. Many of the subscribers in this area were from 30 to 50 miles (48 to 80 km) from the central office. It would be impossible to serve customers at these distances, due to loop losses and the extremely high cost of copper cable.

Once the C.O. locations were chosen, routes were selected to reach the outlying villages and subscribers. Then the quantity of subscribers was cumulated along the routes. These subscriber counts and the distances along the route are fed into the computer S.A.V.E. program which then calculates the costs to serve those subscribers, in the four different methods.

3.5 Example

The following is the physical layout of one of the leads from the Santa Rosa C.O.



The first step in the process is to determine distances along the routes and convert to load points that each distance represents. Second, the cable sizes are determined, based upon growth potential of the area, for each leg of the route. Third, the data is fed into the computer program to obtain the costs per circuit to provide service.

Table 1

		Subs		Per Circuit Cost, $			
Sec	LP	Cum	Cable	Phy	PCM	SLC	STA
1	1.00	276	B400-22	37	925	487	1195
2	1.17	103	B200-22	51	965	561	1196
3	1.28	86	B150-22	61	984	629	1197
4	1.53	73	B150-22	83	927	693	1200
5	2.48	46	B75-22	187	1084	643	1212
6	4.83	44	B75-22	444	1188	707	1357
7	10.00	32	B50-22	1107	1231	*952	1551
8	15.03	32	B50-22	1932	*1391	1069	*1907
9	15.52	28	B50-22	1995	1520	1183	1938
10	16.27	27	B50-22	2091	1589	1243	1955
11	16.44	14	B18-22	2127	1963	2130	2101

Table 2

		Subs		Per Circuit Cost, $			
Sec	LP	Cum	Cable	Phy	PCM	SLC	STA
8	15.03	32	B50-22	645	1302	1052	1545
9	15.52	28	B50-22	708	1431	1167	1577
10	16.27	27	B50-22	804	1500	1227	1594
11	16.55	14	B18-22	840	1874	2113	1740
12	16.51	9	B12-22	860	2638	3110	1894
13	16.68	6	B12-22	909	3876	4724	2129
14	19.24	4	B12-22	1638	6700	8326	2868

Assumptions:
Growth Rate - 2%
Digital C.O. - Yes
Load Point Spacing - 4.5 KF (1.37 km)
Span Line Repeater Spacing - 6.75 KF (2.06 km)
Annual Charge Factors (PCM, SLC, STA) -
1.947 1.333 2.28
"*" Indicates Breakeven Point

Table 1 is a printout of data which indicates that a crossover point occurs between Sections 6 and 7. Thus, beyond this point is will be cheaper to serve using SLC than physical cable. A second computer run is made from this initial crossover point out to the end of the serving area to see if more electronic sites are justified. In this example, none were indicated past the initial site, as shown on Table 2.

At this point, the engineer evaluated the best possible site for the electronics and choose a site near Covered Wells, which would reduce the loop length to the Mountain Village site. Then the design was completed and finalized with traditional procedures.

This procedure was repeated on each cable run from each central office site in the system. The results of these procedures showed that the most economical method to serve outlying subscribers was with the digital T-carrier systems and subscriber line concentrators, not physical pairs or analog carrier systems. Buried cable was used throughout the design and T-screened cable was used wherever the T-carrier systems were installed. Regular filled cable was used for distribution cable from the electronics site to the customer drops.

3.6 Central Offices

Next the central office equipment was chosen to be of the digital type. This allowed a direct digital interface into the switch from the electronic sites and eliminated the need for a digital to analog conversion at the C.O. Since the C.O. sites would be connected by digital toll facilities, the switch output was through a direct digital interface also. This provided additional cost savings, plus, assured no loss of signal quality through the switch.

3.7 Toll System

The next step in the design was to provide toll facilities for all of the central offices. A microwave system was analyzed as well as PCM carrier and fiber optics systems. Certain mountain peaks had existing microwave sites that fit nicely into a pattern to serve the 3 central office sites and then to connect them to a toll switch in Tucson.

Table 3 shows the corts for constructing a digital microwave radio system, and Table 4 shows the cost of providing the network with PCM carrier over cable routes. The comparison showed that the digital radio system was less expensive and was the preferred method for this system. A fiber optic system using optic cables was looked at, however, it proved to be somewhat more expensive than the PCM carrier on copper cable or the microwave system.

Table 3

Unit Description	No. of Units	Unit Cost	Extended Cost
96 Ch 1X1 2GHz Terminal	2	$43,000	$ 86,000
96 Ch 1X2 2GHz Ti Reptr.	1	$65,000	65,000
192 Ch 1X1 2GHz Terminal	2	$53,000	106,000
OW and Alarm Equipment	4	$ 8,000	32,000
30' SS Tower	1	$10,000	10,000
40' SS Tower	1	$13,000	13,000
Antenna (Waveguide)	6	$ 3,000	18,000
8' X 12' Building	1	$14,000	14,000
DC Power Plant	4	$12,000	48,000
Standby Power	1	$15,000	15,000
Spares	AR	$33,000	33,000
Test Equipment	AR	$13,000	13,000
Commercial Power	AR	$27,000	27,000
Installation		15%	75,000
Grand Total			$555,000
PWAC			$686,403

Table 4

	No. of Units	Unit Cost	Extended Cost
Span Line Equipment			
6 System Housing	38	$ 360	$ 13,680
12 System Housing	17	$ 450	7,650
Line Repeaters	238	$ 90	25,920
Office Repeaters	4	$ 400	1,600
Span Switches	6	$ 500	3,000
Remote Power			
Remote Cabinets	3	$ 5,000	15,000
Powering Repeaters	48	$ 400	19,200
Subtotal			$ 86,050
Spares			8,600
Installation			12,910
Total			$107,560
Outside Plant			
BFC50-22	37.0	$1,425	$ 52,730
BFC50-22	73.9	$2,260	167,010
BFC18-22H	179.5	$ 885	158,860
BFC18-19H	63.4	$1,230	77,980
Rock and Depth	88.3	$1,725	152,320
Total			$608,900
Grand Total			$716,460
PWAC			$772,378

3.8 Design Conclusions

The use of digital electronics greatly reduced the cost of providing service to this area. To serve this large of an area with traditional analog switches and physical cables would have required numerous central office locations and thus numerous switches, each with less than 100 subscribers. This would have required a complex toll network and many routes to interconnect these locations. This would have driven costs so high that the whole project would not have been feasible.

4. FEASIBILITY STUDIES

As a part of the study, the system was designed, feasibility determined, rates estimated and a plan to operate the system developed, including number of employees, staffing positions, responsibilities and salaries. The study indicates a loan of approximately 7.6 million U.S. dollars will be required to construct the system. Single party service will be provided to 1,386 subscribers over the next five years. A two percent loan from the Rural Electrification Administration makes this system feasible. To operate the new system, 10 people will be required. Those include a manager, secretary, bookkeeper, plant superintendent, central office supervisor, central office equipment person, outside plant supervisor, combination men and a draftsman. Two automobiles, four two-wheel drive pickups, and two three-quarter ton four-wheel drive pickups will be required. Headquarters and office facilities are included in the cost estimates, as well as, construction equipment such as a back-hoe and trencher.

5. SUMMARY AND CONCLUSION

The uniqueness of the Papago Reservation did not diminish the need of modern telephone service. While service to the area would not be feasible in many circumstances, through the use of a loan from the Rural Electrification Administration service can be provided.

A system built with the latest technology, digital switching, digital microwave, and digital carrier systems, will be economical and meet the needs of the people.

Providing Telecommunications Services to Remote Aboriginal and Islander Communities in Australia

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1. Abstract

Remote Aboriginal and Islander communities have distinctive characteristics which impact upon the provision of telecommunications services. This paper describes a range of management initiatives and processes adopted to implement a major programme of service provision to these communities. Also included are an approach for establishing adequacy of telecommunications services, the identification of demand relationships, some coin telephone issues and an emphasis on the importance of community consultation in meeting customers' requirements.

2. RURAL AND REMOTE AREAS PROGRAMME

In recent years, Telecom Australia has extended its transmission networks and facilities to the more remote regions of Australia, providing many remote Aboriginal and Islander communities with access to world standard telecommunications services. In these communities the adoption of telephone services has been rapid and has provided a convincing demonstration of their telecommunications needs.

The majority of remote Aboriginal and Islander communities, however, still rely on HF radio-telephone networks which offer limited access and an inferior quality of service. It is generally accepted that these services are inadequate; a major programme has recently been developed to alleviate this situation.

In 1984 Telecom Australia commenced the Rural and Remote Areas Programme (RRAP) which by 1990 aims to convert all remaining rural manual services to automatic (including the replacement of all party lines), and to provide automatic services throughout remote areas where currently none exist. Employing a variety of technologies the RRAP will provide between 35,000 and 40,000 services at a cost of approximately $A400 million (1984 prices).

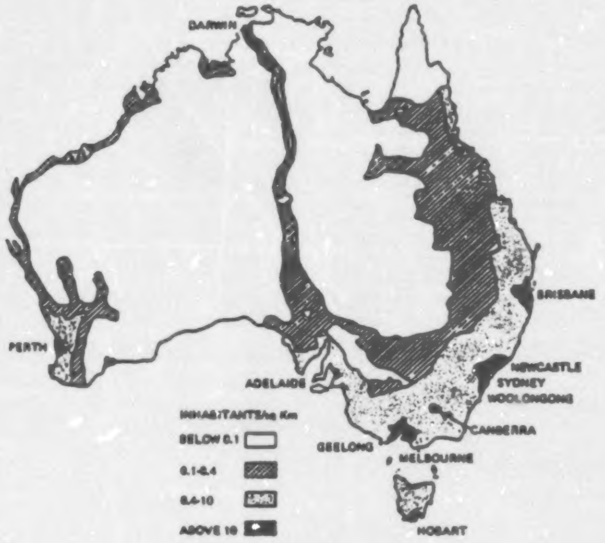
While the majority of services to be provided are in the rural areas, the most challenging component of the programme concerns the remote areas. These areas are currently beyond the reach of the national telecommunications network and have population densities less than 0.1 inhabitants per square kilometre (refer to Figure 1).

Customers include pastoralists, various agricultural enterprises, government agencies, some tourist and mining ventures and Aboriginal and Islander communities. The provision of services to these customers requires new systems, special organisational arrangements and substantial financial outlays.

3. REMOTE ABORIGINAL AND ISLANDER COMMUNITIES

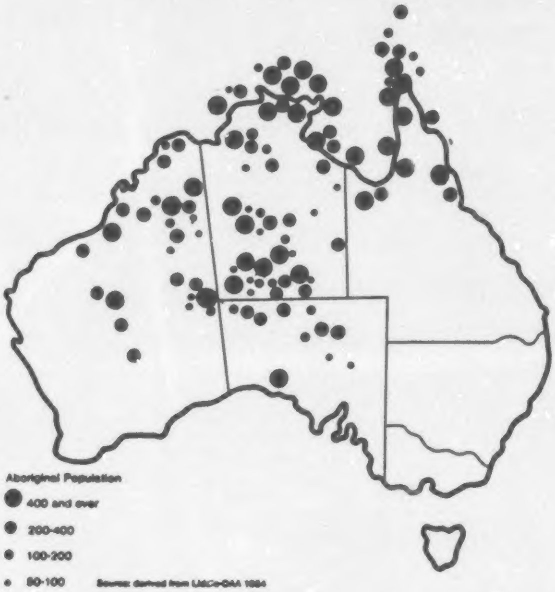
Aboriginal and Islander communities are major customers, containing two thirds of the total remote area population. They are located throughout Australia in island, costal and desert regions (refer to Figure 2).

FIGURE 1: POPULATION DENSITY IN AUSTRALIA



Source: Telecom Australia

FIGURE 2: ABORIGINAL AND ISLANDER COMMUNITIES IN REMOTE AUSTRALIA



Source: Task Force on Aboriginal and Islander Broadcasting, 1984

These communities are both remote in terms of distance from the existing telecommunications network and accessibility to their nearest service centres. Their size can range from small pastoral camps of maybe 30 people through to major settlements with populations greater than 1000. There are at least 80 communities with populations greater than 200 to be served during the programme.

Remote Aboriginal and Islander communities have a number of distinctive characteristics which are relevant to the provision of telecommunications services and require special consideration.

Climatic Factors

Climatic conditions encountered include heavy rainfall, strong winds, bushfires, salt air, extremes of heat and lightning. These conditions pose problems for service reliability and access to communities for both provision and maintenance purposes. During the wet season some communities may be inaccessible, except by helicopter or boat.

Linguistic Diversity

There is a great diversity of languages spoken between and often within remote communities. English is secondary to about 50 major Aboriginal languages being used throughout Australia, plus another 100 languages in minority use. This situation poses special problems for customer consultation and the preparation of service information material.

Relationship to Land

Traditional rules govern a community's relationship with its land, determining 'ownership', responsibilities for management, and permitted use. In particular, certain sites have sacred significance and care must be taken to avoid violating them when providing telecommunications services.

Organisations and Infrastructure

In most communities there is a core of organisations (i.e. Council, Health Clinic, School, Shop), plus a range of other organisations depending generally on population size, settlement history or strategic importance (e.g. Church, Workshop, Power House, Police Station, Post Office, Women's Centre, Social Club, Craft Business, and so on). This organisational diversity has to be acknowledged when forecasting demand and in providing for the special needs of each organisation.

Public utility infrastructure varies between communities. For example, some smaller communities have no central electricity supply. In these circumstances some terminal products are unsuitable and cannot be offered. In other instances electricity supplies are unreliable or faulty and can damage telecommunications equipment. In addition, the underground reticulation of water, sewerage and electricity can be poorly documented and co-ordinated,causing problems for community cabling.

Economic Base

In most instances remote communities are heavily dependent on external government funding (viz. town management grants, special subsidies and support schemes for community or business activities, and welfare payments providing personal incomes). This must be taken into account when considering the ability of communities to pay for telecommunications services. Local enterprises do exist in many communities, however, and they are likely to become more significant in the future. As well as retail, construction and craft activities within communities, there may be other industries concerned with tourism, fishing, cattle or mining. Even so, unemployment within communities remains high.

Physical Layout

Remote communities generally have a major population centre with clearly delineated administration complexes, community facilities and living areas. There will usually be a number of physically discrete living areas, often in accordance with different family groupings. Communities may also have substantial hinterland populations living in small settlements ('outstations') clustered for distances up to about 100 kilometres or so around the major population centre. Some of these 'outstations' could ultimately become autonomous community entities. Remote communities may also have significant links with town camps located on the verges of major urban centres.

Access to telecommunications services is affected by the physical layout of communities. A compact community may require fewer services than one of the same population size that is dispersed over a larger area.

Population Mobility

The populations of remote communities demonstrate a high degree of mobility, particularly between major population centres and related hinterland 'outstations' or urban centre town camps. In tropical regions the dry season population of the major centre may be dispersed among its outstations for social or ceremonial purposes. During this period, taking account of the major centre's population alone could result in a serious underestimate of community telecommunications needs.

Service Experience

General awareness of telecommunications service options is low in remote communities, even where they have had experience of standard automatic telephones. Many remote communities have only experienced HF radio-telephones, where access is restricted and quality of service poor. Understandably they tend to feel that the provision of even one automatic telephone would bring them substantial benefits. When offered high quality services, therefore, they are likely to severely underestimate their real needs.

Future Developments

The longer term future of remote communities is uncertain, being dependent on many diverse factors including the provision of telecommunications services.

Community development and communications are inextricably linked, although the nature of this relationship resists clear description. For the purposes of demand forecasting in particular, and for more general social impact analyses, it needs to be better understood. This is particularly so given the opportunities for innovative activities presented to remote Aboriginal and Islander communities by impending technological developments in voice, data and broadcast services.

More specifically the relationship between broadcasting and telephony deserves special consideration as many remote Aboriginal and Islander communities will receive satellite broadcasting before they have access to standard automatic telephone services.

The uncertainty of future remote community developments poses a very real obstacle to longer term planning in a commercial environment. However, this should not be allowed to deny remote communities the opportunity to adopt innovative telecommunications services to achieve their own aims.

4. COMMERCIAL STRATEGY

Telecom Australia's Rural and Remote Areas Programme (RRAP) seeks to provide telecommunications services to any customer who may reasonably want them. However, as the high costs of provision, operation and maintenance of rural and remote services cannot possibly be met by the revenue they generate, a commercial strategy which both achieves this aim while maximising financial return is crucial.

As installation costs are high in remote localities, considerable savings can be made if adequate services for all customers are provided in the first instance, along with sufficient capacity for future growth. This is important in remote Aboriginal and Islander communities where lack of familiarity with telecommunications services results in underestimation of demand, with requests for additional services quickly following the initial provision. This leads to higher overall costs of provision as well as to loss of revenue from insufficient access to services.

The commercial strategy adopted for the Rural and Remote Areas Programme, therefore, is one of optimising market penetration and, by ensuring customer access to services, one of maximising revenue through subsequent network usage.

5. ESTABLISHING ADEQUATE SERVICE

On the basis of past service experience in Aboriginal and Islander communities it has been possible to establish what constitutes adequate service. Adequacy can be specified in terms of an appropriate mix and level of business, public and residential services, thus ensuring access for all community members. It can be further qualified in terms of the attributes of these services.

For example, cost control is an important attribute of business and residential services. It can be affected by cultural attitudes to the sharing of resources and level of experience with accounting and budgeting. In particular, community people responsible for a service can often find themselves under pressure to allow uncontrolled use of the service. Easy access to coin telephones helps to alleviate these pressures.

Physical location and 24 hour access are important attributes of coin telephone services. While in the short term the majority of Aborigines and Islanders in remote communities may not seek residential telephones, they are heavy users of telecommunications services and wish to have ready access to them.

6. FORECASTING DEMAND

The longer term uncertainty surrounding the future of Aboriginal and Islander communities and their limited experience of telecommunications services to date pose the major problem of how to forecast demand for their initial and developing community needs.

It is clear that although in the longer term substantial demand is possible, this depends on a complex array of factors. Demand for services could suddenly 'take-off' but there is no reliable way of estimating the timing and nature of such an occurrence. Accordingly demand forecasting for the RRAP is being limited to a time horizon of about ten years.

Business Demand

Demand for business services is clearly related to the number and nature of service organisations and businesses within a community. Larger organisations may require several services, whereas in small communities some service sharing may be envisaged. There is already some demand for data and telex services. Demand for other text and document transfer services is anticipated.

Public Demand

This is best related to the number, size and population of living areas within a community. Many remote communities have locally identified and named living areas and these represent socially meaningful entities for the planning of coin telephone services. To ensure effective access, large or heavily populated living areas may require more than one service.

Residential Demand

There is an emerging demand for residential services from Aborigines and Islanders in remote communities. This demand is best related to employment and business opportunities within the community concerned. The approach used at this stage is to view residential demand as some function of community organisations and businesses, with the number of organisations and businesses providing a surrogate upper limit to potential demand.

7. COIN TELEPHONE ISSUES

The provision of adequate telecommunications services to remote Aboriginal and

Islander communities will rely heavily on the provision of coin telephones. While extensive provision of business services is anticipated, residential penetration is not likely to be high in the short term; this is because of low per capita incomes, unsuitable housing, a general concern in communities that usage could not be easily controlled, and a perceived burden of having to take in-coming messages if not many other households have a telephone. Community people, therefore, will require easy access to coin telephones.

There are a number of problems associated with the provision of coin telephones in remote locations and there are various options for service provision.

Coin Circulation

There have been some reports of coin shortages in remote communities and a concern that coin telephones could either be impractical or exacerbate the situation by taking coins out of the community.

Coin Box Clearance

Heavy use of coin telephones requires frequent coin box clearances. To the extent that these clearances are not made immediately access can be severely diminished.

24 Hour Access

The location of coin telephones in buildings that are locked up outside business hours impedes access at a time when community members wish to take advantage of cheaper STD rates, or contact people who cannot be reached during the day. As noted above, 24 hour access is also denied if coin boxes are not cleared.

Reverse Charge Calls

A potential problem with coin telephones is the irresponsible acceptance of reverse charge calls.

Service Reliability

Recurring faults can diminish the acceptability of coin telephones. For example, the confidence of users is shaken by facilities being frequently out of order, and blocked coin shutes impede access. A fast maintenance response to coin telephone faults is vital.

Service Options

Three broad options for coin telephone provision have been tried and evaluated : viz. leased/purchased by the community concerned, public provision under normal arrangements, or public provision under special arrangements. With public provision under normal arrangements, the public telephone coin box leaves the community unopened and is replaced with an empty one; whereas under special arrangements the coin box is opened within the community, and the takings (less a 10% fee) are remitted by cheque. A similar arrangement to the latter applies to leased/purchased services, with the exception that the community is actually billed for calls made.

At this stage the preferred option for the RRAP is the provision of public telephones under special arrangements. A community telephone policy is currently being developed, specifying this option and related special arrangements.

8. COMMUNITY CONSULTATION

Community consultation assumes a greater significance with the provision of telecommunications services to Aborigines and Islanders than is usually the case with other customer groups. Reduction of uncertainty and the achievement of adequate service provision can only be attained by close consultation with each community in turn.

The Rural and Remote Areas Programme is dealing with remote Aboriginal and Islander communities as collective entities. This approach recognises their overall community telecommunications needs and assesses demand accordingly, rather than assuming that unsolicited applications for service provide an adequate expression of demand.

It has been necessary to develop a cross-cultural consultation process, therefore, capable of addressing a wide range of issues and able to be integrated into the overall planning and construction programme. This process also has to be effective over a heterogeneous group of communities covering an extensive geographic area.

The consultation process developed has several distinctive features.

Presentation of Service Information

Information on service options is being packaged in community terms for presentation in a fashion conducive to collective decision-making, rather than individual decisions on a customer by customer basis.

The objective is to prepare in an integrated fashion all the necessary information for a community to make a considered assessment of service requirements, without understating their demand, getting their priorities wrong, or entering into unsatisfactory arrangements.

The emphasis is being placed on specifying the mix (business, public, residential) and level of services that the community needs to consider, given variations in community characteristics; this will highlight relevant service attributes, available service training and customer education, and potential local land issues associated with facilities location, site acquisition, construction and cabling.

Consideration is being given to ways of addressing the linguistic diversity and varying levels of literacy and English language competence encountered in remote communities. Supplementary video material is currently being produced to assist forecasting and sales consultations by demonstrating service applications in context, and highlighting the issues a community needs to consider.

Compatibility with Community Decision-Making

Care has been taken to develop a consultative process that is compatible with community decision-making processes. Elected community bodies provide the focus for customer consultation activities. Traditional land owners also reside within communities and are consulted on any matters concerning land use. Consultation with other community interests is arranged through the Community Council, with the latter being responsible for the co-ordination of community decision-making.

Aboriginal and Islander communities have expressed a preference for a two stage decision-making process, with service options being presented during the first consultation and decisions finalised during the second. Indications are that given clear presentation of options not a lot of time is needed to reach a decision. Generally about a month is being allowed between consultations.

Sensitivity to Land Use Issues

The consultation process is sensitive to land use issues arising from a community's relationship to land. A complex of legislation, both Federal and State, affects issues of traditional land ownership, protection of sacred sites, preservation of archaeological and cultural sites, and environmental impacts. This legislation and its administration are politically contentious issues likely to remain in a state of flux throughout the period of the RRAP.

Thorough operational procedures are being developed to deal with all aspects of land use and acquisition. As noted above, traditional land owners are included in all community consultations to ensure their interests are respected in the location and installation of equipment within a community.

To establish sites for transmission bearers a corridor planning approach is being adopted that allows for consultation with traditional land owners within the proposed corridor, prior to any preliminary field surveys. As part of this approach a land use video is currently being produced to provide a clear demonstration of all surveying, construction and maintenance activities that have potential land use impacts. Content will derive from a comprehensive filming of the first Digital Radio Concentrator System installation in a remote area.

9. PROGRAMME MANAGEMENT PROCESSES

Although well integrated with Telecom Australia's overall planning, programming and budgeting processes, the scope and national significance of the Rural and Remote Areas Programme necessitates its separate identification and management. A comprehensive management process has been implemented, therefore, to guide it to a completion target of 1990.

Commercial Targets

For each of the six years of the programme (1984-1990) commercial targets are being set for the number of services to be provided. The targets derive from demand forecasts and reflect commercial strategy, forming a basis for monitoring annual construction and connection progress. A national management information system has been established to provide a regular flow of relevant planning data, including an early indication of any variance between actual performance and established commercial targets.

Commercial Management Policies

The special characteristics of the RRAP and the environment it is serving have necessitated the development of a wide range of special policies, promulgated within Telecom in a series of special publications. These have covered the co-ordination and monitoring of the programme across Telecom's regional operations; the various marketing, sales, promotion and advertising strategies; manpower planning and staff training requirements and environmental assessment procedures.

As the programme gets fully underway and various organisational structures become operational, more detailed and long term issues will be addressed. Among these are the development of fault reporting and testing systems; the establishment of maintenance standards; the determination of purchasing and leasing policies and other aspects of commercial arrangements; the design of coin telephone enclosures appropriate to the various climates and the consideration of terminal products which allow for non-standard electricity supply and interference by tropical storms.

Aboriginal and Islander Policies

Detailed policies on the provision of services to Aboriginal and Islander communities have been prepared. These deal with general consultative procedures, demand forecasting, sales consultations, land use, manpower and staff training. A general process for service provision is outlined with a checklist for related activities.

An orientation programme is currently being prepared to provide all staff serving Aboriginal and Islander communities with an awareness and appreciation of these contexts and their telecommunication needs. A specific programme is also being developed for field staff to train them in customer consultation procedures. This will elucidate aspects of cross-cultural communication.

10. CONCLUSIONS

Telecom Australia's Rural and Remote Areas Programme will provide world standard telecommunications services to remote Aboriginal and Islander communities within an assured time frame. These communities have demonstrated a substantial demand for telecommunications services which has required the development and implementation of special policies and management processes sensitive to the distinctive characteristics and needs of the communities concerned. Particular emphasis has been placed on community consultation as the means of ensuring the provision of adequate numbers and types of services in the most efficient and effective manner.

The organisational momentum of these programme arrangements is just becoming evident and their full impact is yet to be realised. Nevertheless it is recognised that continuing to meet the requirements of remote Aboriginal and Islander communities will require modification of the approaches outlined in this paper, and their further expansion to meet emerging issues.

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POINT-TO-MULTIPOINT DIGITAL SUBSCRIBER RADIO SYSTEMS FOR RURAL AREAS IN CHINA

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ABSTRACT

Point-to-multipoint digital radio systems offer a means of providing economical telephone services in rural areas in China. The paper describes a design and feasibility study being undertaken jointly by researchers in Shandong University, China and in Adelaide, Australia. The study is examining subscriber radio systems such as those currently under development in Australia, France, Japan and Canada for use in remote areas. This paper examines some of the special problems associated with the design of systems suitable for the rural areas of eastern China.

1. INTRODUCTION

Telephone and data transmission services in China are currently at an early stage of development and concentrated mainly in the city areas. Although over 80% of the population live in rural settlements, telephone services to many agricultural regions are very limited. In many villages the only telephone service consists of a single manual telephone set connected to an open-wire pair. In some villages, no telephone service yet exists.

China is currently giving priority to the expansion of telephone services in 12 of the larger cities including Beijing and Shanghai (1).However in many rural areas the provision of extensive transmission and switching facilities by conventional means cannot be expected to occur for some time.

In the interim period, it may be possible to provide high quality telephone services to a limited number of users by employing modern digital systems based on point-to-multipoint (PMP) radio equipment. Systems of this type are currently undergoing development in other countries including Australia, France, Japan, Canada, England and New Zealand (2-8).

These systems rely on microprocessor-based equipment for digital encoding, control and switching. All speech signals are encoded into digital form and transmitted by digital radio systems using time division multiplexing with multiple access on demand.

The systems operate in cellular arrangements. In any one cell, subscriber radio units communicate with a base station in a point-to-multipoint configuration. Telephone conversations are transmitted via digitally modulated time slots on a single radio frequency. Transmitters are turned on and off in sequence to permit each to sequentially transmit a burst of digital signals to the base station in the cell.

Linear, star or tree network configurations can then be used to interconnect base stations to each other and to a regional telephone exchange either directly or by digital radio.
Various terms have developed to describe such a system, including

* Digital radio concentrator system - DRCS (Telecom Australia)

* Digital remote area subscriber radio telephone system - Digital RSS (NEC Corporation), and

* Integrated rural telephony system - IRT 1500 (Philips)

In China, it may prove cost effective to utilize these systems in regions of low population density or in regions where subscriber cable services cannot be provided. The current research program is concerned with the development of digital radio subscriber PMP systems for the rural areas of eastern China. Figure 1 shows the Shandong Province region concerned in the study.

In addition, it is intended to examine the feasibilty of using these techniques to provide high quality telephone operation for selected centres in some harbour cities such as Quindao, Dalian and Yantai. These newly opened cities urgently need modern telecommunication services to meet demands resulting from their developing international business centres. Many of these are located in suburban areas where conventional high quality telephone connections cannot be quickly realized.

The research and development program is being undertaken cooperatively by engineers at Shandong University, China and at The South Australian Institute of Technology, Australia. The cooperative program was initiated during a visit to Shandong University by Associate Professor Miller under the Chinese University Development Program, a program designed to strengthen teaching and research in the engineering disciplines in selected Chinese universities.

2. POINT-TO-MULTIPOINT SUBSCRIBER RADIO SYSTEMS

Digital subscriber PMP radio systems in current development allow the connection of telephone users to a terminal telephone exchange over distances up to 600 km. They are transparent systems. That is, a user connected to an exchange via a PMP system is considered to be the same as any other subscriber connected to the exchange by conventional means. The digital radio circuit transmission quality should be indistinguishable from a standard high quality physical circuit.

A single PMP subscriber radio system connects users via one or more radiotelephone nodes to a central exchange. The system is arranged on a cellular basis with a nodal transceiver at the centre of each cell serving users in that cell on a point-to-multipoint basis. Each cell may extend over an area of radius 25 to 40 km. This is illustrated in figure 2.

Cell nodes are able to repeat traffic from one cell to the next, enabling several cells to be interconnected and to terminate at a telephone exchange. All the telephone users in any one PMP system must share a limited number of channels, typically 15 both-way circuits.

A PMP system typically consists of three types of subsystem units. These are

* the 'subscriber unit', located at the users' premises,

* a 'repeater unit', the central node for each cell that is remote from a local telephone exchange, and

* an 'exchange unit', which will be located at a telephone exchange and may also fulfill the role of a node for a radio cell in that area

The subscriber unit consists of a digital radio transceiver and large-scale integrated (LSI) circuits for control, coding and multiplexing of voice signals. Typically the subscriber antenna is mounted on a 10 m pole or guyed mast. Where 240V ac power is not available, the power requirement can be supplied from batteries and associated solar array panels. If solar power is used, the solar array will typically feed two 90 ampere-hour 6V batteries which will provide an 8-day reserve.

If desired, more than one telephone user can be connected by local lines to a single subscriber radio unit. Up to 21 users can be accomodated in this way by one subscriber unit radio transceiver.

Each subscriber unit in a given cell is generally located within a radio line-of-sight path from the nodal station which acts as the radio base for that cell. The nodal station is referred to as an exchange unit if it is located at the terminal exchange. Otherwise it is known as a repeater unit.

In reasonably flat rural terrain, the spacing between nodal stations is typically 40 to 60 km. Each nodal station acts as a regenerator and is able to communicate by radio with an exchange unit via one or more adjacent nodal stations.

Many PMP subscriber radio systems use the frequency band from 1427 to 1525 MHz with channel spacing of 2 MHz. This band has been allocated for rural telecommunications and provides a maximum of 24 two-way radio frequency channels (9).

The use of digital transmission together with time-division multiple access (TDMA) techniques allows maximum conservation of frequency use. In any one cell of a PMP subscriber radio system, only one frequency pair is used.

Communication from nodal stations to subscriber stations is in the form of a time division multiplexed signal structured into time frames, each being typically 4msec long. Each time frame is divided into n slots where n is usually in the range 11 to 16. One slot is used for signalling and the other n-1 slots are available as speech channels.

In the other direction, subscriber stations transmit in burst mode. That is, their radio transmitters are switched on and off in bursts and transmit the digital signals at rates typically in the range 700 to 850kbit/s.

The entire PMP system is controlled by the exchange unit for that system. This microprocessor-based exchange unit interfaces the PMP system with the telephone exchange. It provides for synchronization, channel assignment and fault diagnosis for the whole PMP system.

The exchange unit contains two subsystems - a concentrator and a time division multiplex controller. The concentrator ensures that all telephone, data and telex signals in the PMP system are concentrated into the n-1 available time slots or channels. It controls the call sequence and allocates the time slots to the callers. It consists of a central processing unit controlled by a stored program.

The time division multiplex controller in the exchange unit provides timing and transceiver control for all radio units in the whole PMP system. It transmits control signals to switch transceivers on and off.

A repeater unit receives and regenerates the signals transmitted from the exchange unit. Then it transmits them on a different frequency not only to the subscribers inside its transmission cell but also, if applicable, to a neighbouring repeater unit for further repetition. Signals in the opposite direction, from telephone user to local exchange, are repeated in a similar manner.

Each repeater unit will have at least two antennae. An omnidirectional antenna is used for communicating with the users inside the repeater's cell. A second directional antenna will be used for communicating with the next adjacent repeater unit or with the exchange unit at the local telephone exchange.

The traffic capacity of a PMP system with 15 available speech channels is such that it can provide a satisfactory grade of service for a maximum number of 128 subscribers (4). This assumes an average both way calling rate of 0.06 Erlangs per service, such as for mixed business or residential services. Where the traffic intensity is higher (say 0.09 Erlangs per service, such as for businesses or public telephone services), the loading per PMP system should be reduced to approximately 80 subscribers.

3. GEOGRAPHICAL CONSIDERATIONS IN EAST CHINA

In the rural areas of eastern China, the population density is relatively high compared to other rural regions of the country. This is true, for example, in the Shandong Province, even in its mountain areas. As illustrated in figure 1, the southern part of Shandong Province contains large mountain regions. Hilly landscapes dominate the eastern parts and the remainder contains flat farming regions. There are 14 cities in Shandong. Three of them (Jinan, Quindao, and Zhibo) have populations in excess of one million. The others each consist of .3 to .5 million people.

Each city is the centre of a district consisting of from 4 to 14 counties. A county consists of an area typically 50 km in diameter, contains approximately 800 villages, and has a total population of .75 million. The villages located in the flat regions each contain on average 500 to 1000 people. Those in the mountain areas average typically 10 to 100 people. Distances between villages average 2 km in the flat regions, 5 km in the hilly parts and 10 km in the mountains.

As a result of new economic policies for the rural areas, many farmer families have begun household side-line production of goods such as pigs, poultry and manufactured goods. Their needs for information on marketting and sales are rapidly increasing. This is escalating demands for domestic telephone services in rural areas. An initial provision of one good quality service for each village for example, would provide for essential domestic and business communications until a more conventional infrastructive of higher density services can be developed.

Conventional PMP digital subscriber radio systems appear to be readily applicable for use in the mountain regions of east China. They also would be useful in the west of the country where the population density and village numbers are much lower than in the east.

They are less attractive for the more populated flat eastern rural areas. This is because of the restriction of user numbers to approximately 128 per PMP radio system. With a radio cell diameter of 60 km, each cell will extend over little more than one county. In order to provide even one service per village, it will be necessary to consider the following options:

* restriction of each PMP system to just one cell with separate transparent digital links to connect nodal stations in each cell to the terminal telephone exchange at the district centre as illustrated in figure 3

* offering a much reduced grade of service in order to increase subscriber numbers

* increasing the PMP system's transmission bit rates to permit a significant increase in the number of time slots (working circuits) available in any one system

* utilising more than one PMP system in each cell.

The feasibility of these and other system design variations are being considered in the research currently being undertaken. The study includes consideration of equipment complexity and costs.

The average cost per telephone service in a PMP digital radio system is a function of the configuration of the network and of the user density. Where all or most of the users for any one PMP system are all located in one radio cell, the user density will be of the order of 120 subscribers per radio cell. This relatively high density is equivalent to 0.06 users per square km or to an average user separation of R = 4.1 km.

It has been found in some other countries that for this value of user density, the cost per service of a PMP subscriber radio system is approximately the same as that for a conventional cable system. This is illustrated in the following table (2).

Av. user separation (km)	3.2	3.8	4.1	5.8	10.0
No. of users per radio cell	200	140	120	60	20
PMP system relative cost per user	1.0	1.0	1.0	1.0	1.0
Cable system rel. cost per user	0.8	0.9	1.0	1.4	2.3

The PMP radio system cost per user remains essentially independent of subscriber density or user separation. This is true for densities down to 20 users per radio cell. On the other hand, the cost per service of a conventional system based on buried cable local loops can be 100%

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greater or more for a user density equivalent to 20 subscribers per cell. That is equivalent to an average separation of 10km or 0.01 users per km.

It is expected that for some regions in Eastern China, it may be desirable to consider the use of PMP radio systems to provide for user densities considerably greater than 120 users per radio cell. This may be desirable especially if the PMP radio systems can be installed more quickly to meet urgent demands than conventional systems.

Such a situation has developed in regard to 14 harbour cities in China, including Quingdao, Tsingtao and Yantai in Shandong Province. These cities may be designated 'open' for international trading companies. As a result, there will be an urgent need to provide for reliable, high quality telecommunication services to selected points in these cities as soon as possible.

Research is continuing into the feasibility of using various strategies to increase the number of users per PMP service. This might be assisted by the use of digital radio systems with much higher bit rates than those conventionally used. Radio interference problems are also significant. A major interference problem may occur between radio cells using the same frequency allocations. The use of the 19 or 22 GHz frequency bands in city areas may be appropriate (6,7).

4. CONCLUSIONS

Digital point-to-multipoint radio systems have the potential to provide high quality telephone and data transmission services in eastern China. They are especially suited to environments where the telephone user density is relatively low. They take advantage of modern digital transmission techniques to provide high quality service with maximum conservation of frequency spectrum use. In China, these systems appear to have potential for providing a cost-effective low density telephone service in rural areas. They appear especially suitable for those regions where few conventional services exist.

The PMP digital radio systems are relatively compact and involve relatively low installation times compared to more conventional cable distribution systems. As a result, PMP systems offer a means of providing an initial telephone service infrastructure to selected points in regions of high population density. They may provide a means of satisfying urgent initial needs until more conventional telephone distribution systems can be installed.

Design and evaluation of digital subscriber radio systems are at an early stage in several other countries. So far they have been developed to serve remote or rural areas of low population density. Future research into extensions of the fundamental structure of these systems may lead to systems suitable for application in countries with high population density. They may provide a means of satisfying high priority telephone and data transmission requirements quickly and efficiently where a conventional telecommunications network is unavailable.

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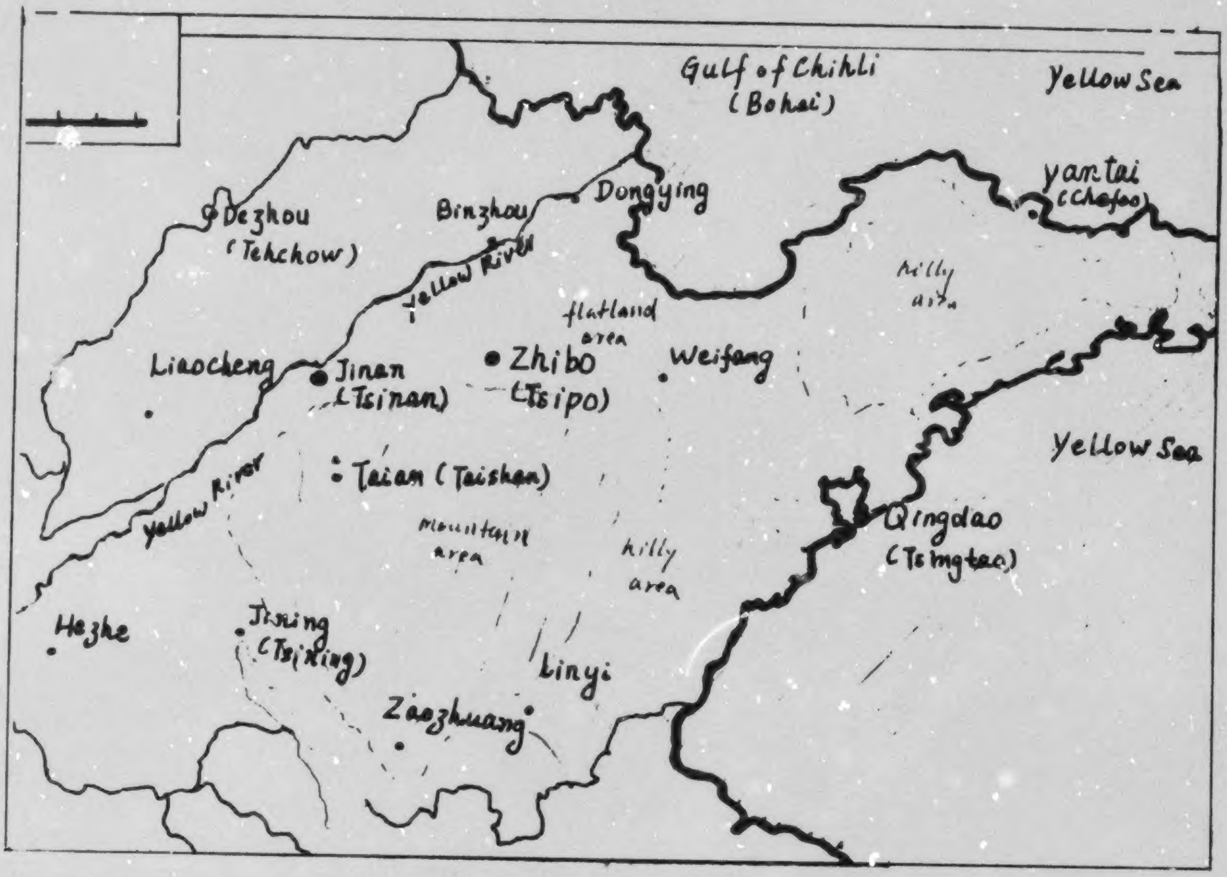
Gulf of Chihli
(Bohai)
Yellow Sea
Yantai
(Chefoo)
Dezhou
(Tehchow)
Binzhou
Dongying
Yellow River
hilly area
flatland area
Liaocheng
Jinan
(Tsinan)
Zhibo
(Tsipo)
Weifang
Yellow Sea
Taian (Taishan)
Yellow River
Qingdao
(Tsingtao)
mountain area
hilly area
Hezhe
Jining
(Tsining)
Linyi
Zaozhuang

Figure 1 : Shandong Province, China.

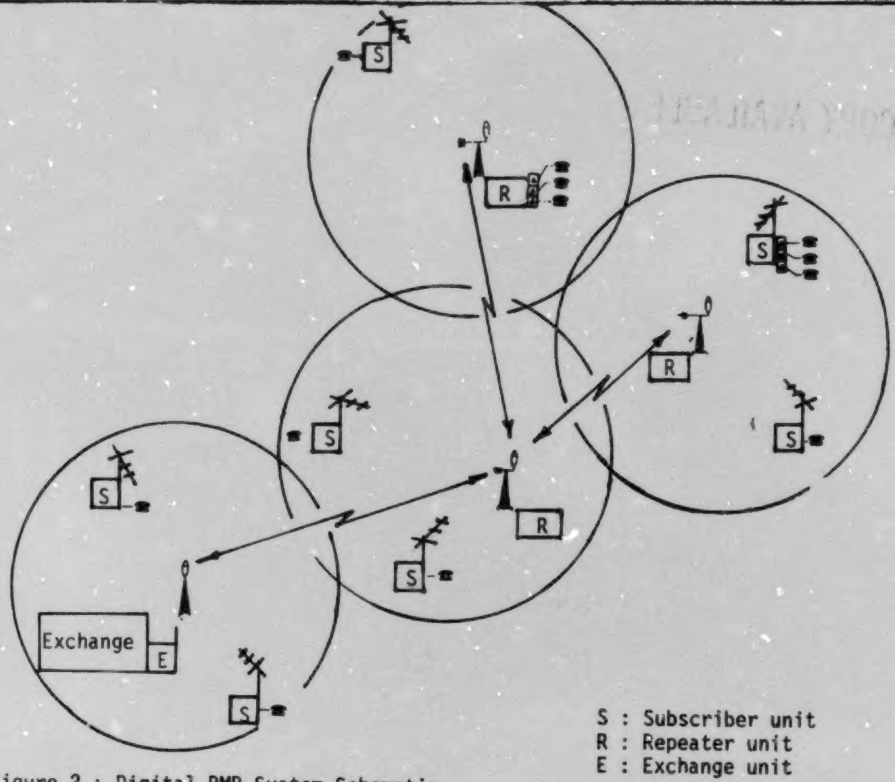
S
R
S
R
S
S
S
R
Exchange
E
S
S : Subscriber unit
R : Repeater unit
E : Exchange unit

Figure 2 : Digital PMP System Schematic

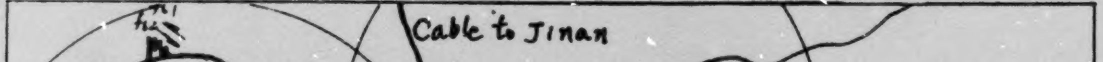
Cable to Jinan
SUB
F1
F2
S6
village
F1
F2
MS
District city
Cell 2
Repeater
F1
F2
F3
F4
Cell 3
SUB
village
local exchange
County
S1
SUB
village
SUB
village
Cell 1

Figure 3 : A possible system configuration

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DIGITAL REVOLUTION IN INDIA - A PERSPECTIVE

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1. Abstract

The paper envisages in brief the so-called computer "rush" in different walks of Indian Society. This paper also reviews the events leading to the current modernisation strategy and outlines possible future developments that may further improve the existing position. It presents a general picture of India in its quest for digital electronic alternatives. The aims and objectives of a scheme popularly known as CLASS has been described.

2. INTRODUCTION

As in other developed and developing countries, commerce and industry in India are becoming increasingly dependent on fast, flexible and reliable processing and transmission of information. Electronic alternatives such as electronic mail, word processors and the like are quickly replacing traditional methods of communication that involve time-consuming and costly movements of paper and people. Rapid advances in technology have led to the availability of a comprehensive range of sophisticated new customer-located products to augment the basic telephone for business and social purposes. These customer services require a general purpose network that has the capacity and flexibility to respond to rapidly changing customer requirements. Keeping this in mind, an integrated digital network is proposed in the seventh five year plan (1985-1989). It will also provide an improvement in the quality of service which is possible through speedier fault clearances in digital electronic switching and transmission systems.

For quickly identifying troublesome local and long distances junctions by automatic scanning process, the four metro telephone districts of Bombay, Calcutta, Madras and Delhi are going to have special computerised testing equipments called AUTRAX (Automatic Traffic Analysing Complex). The introduction of in-house computers at these four metro centres is also helpful in taking care of a number of functions like directory assistance, telephone billing, inventory control, personnel management, etc. Plans are under study for taking benefits of digital application to the vast rural communities during the seventh five year plan.

The recommended modernisation strategy requires new high-capacity digital systems to be installed not only to meet network growth, but also to progressively replace all existing analog systems over a period of about a decade. This will create a greatly increased demand for digital systems during the modernisation period. To achieve these aims, it will be necessary to exploit all available resources and it is of paramount importance to take advantages and benefits of technological advances, particularly by maximising the use of optical fibre systems. The infusion of this new technology into society is likely to create hundreds of thousands of new jobs. Some estimates suggest that 75% of Indian jobs will require some knowledge of computers by 1990.

With these factors in mind, there has been a computer "rush" in all walks of Indian society. A recent study has revealed that more and more people are taking to basic courses in computers and there has been a general awareness in every average individual. In India, a pilot scheme is being carried out to educate and familiarize computer through computers and it is expected that within the next decade individual CAI (Computer Aided Instruction) will be widely used in elementary schools for reading, spelling and arithmetic.

This paper reviews the events leading to the current modernisation strategy and outlines possible future developments that may futher improve the existing position. It presents a general picture of India and its quest for digital electronic alternatives. In what follows, a description is given of the various schemes of the government and their social impact on the people of India.

3. ORGANISATIONS WORKING IN THE AREA

This section describes several public and private sector organisations responsible for introducing the digital era in India. The P&T Department is one which has shown great promise. The R&D organisation of the telecom wing of P&T Department, known as TRC (Telecommunication Research Centre) has grown into a large organisation dedicated to the work of telecommunication development. Its activities include:

- assessment of the needs of the telecommunication network so as to introduce the appropriate new technology;
- development of equipment and telecommunication systems using digital technology; and,
- to coordinate and assist with manufacturing agencies in the country to meet P&T systems requirements.

Various equipments incorporating latest digital technologies have been developed at this centre. They include:

- large capacity transmission media such as digital coaxial, digital radio and optical fibre communication systems;
- small capacity electronic exchanges for rural applications using micro-processors;
- The Store and Forward (SFT) system installed at CTOs in Madras, New Delhi and Hyerabad;
- 2Ms/s digital line equipment; and,
- 8448 K/bs PCM MUX and 34 MB/s Digital MUX.

Different groups of TRC such as PCM group, Radio division, Satellite division, Electronic Switching divison, Technology absorption division, Software and the system selection group, are carrying out research at various levels to realise the dream of a digital communication network.

Other notable contributors in this area include Indian Telephone Industries Ltd., Bharat Electronics Ltd., Electronic Corporation of India Ltd. and Hindustan Teleprinters Ltd. to name only a few. These organisations have been fulfilling the country's demand for manufacture of telecommunication equipment and Teleprinters. The R&D Expenditure of ITI, BEL and ECIL is given in Table 1.

TABLE 1.

R&D EXPENDITURE OF ITI, BEL & ECIL (5)
(in crores of rupees)

Company	Turnover 1971-72	 1977-78
ITI	235	855
BEL	336	746
ECIL	36	298

Company	Expenditure on R&D 1971-72	 Exp. as % of turn over	 1977-78	 Exp. as % of turn over
ITI	7.5	2.2	56	6.5
BEL	9.6	2.9	45	6.0
ECIL	0.6	1.6	12	4.0

4. SOCIAL IMPACT

Like in all other countries, the impact of digital electronics has been profound and has left its mark on India's society. It is playing the most important role in technology and has penetrated almost all branches of science. Computers perform some of the functions of the brain; they accumulate store and process information in accordance with a logical program drawn out by man. Moreover, fast means of communication have caused a revolution in time-space relationship in the popular sense. Thus, society is largely shaped by the impact of digital electronics and new forms of technology.

In India, the Department of Science and Technology is working for and giving maximum attention to involving a large cross-section of society in science and technology related activities. In this direction, it is introducing various schemes from time to time. Some of these are:

- Computer literacy and awareness in school students. Detailed in section 5;
- Promotion of Scientific Interest in Youth. This scheme was initiated to help spread the culture of science tailored to the needs and conditions of the Country. An advisory committee to advise the government has been constituted. Participation

of young scientists in Seminar/Symposia, travel for participation in International Conferences, Research Projects and awards to deserving young scientists are the areas where maximum encouragment and help are available;

- Science and Technology for Women. Sustained effort at improving the living conditions of women by application of science and technology has been the motto of the Indian Government in this project. Programmes for reducing drudgery, fuel and cooking systems, training programme particularly for generation of gainful employment, and programmes related to health and nutrition are carried out under this scheme;

- Technology Development for Weaker Sections. The objectives of this scheme are directed towards the promotion and development of technology for occupations engaging artisans, landless labourers and the economically weaker section of society. The fabrication of solar cookers by potters and blacksmiths have been one of the major achievements of this project; and,

- Future Research. The programme's emphasis is placed on subjects that have long term impact on society. A study on rehabilitation aids for disabled and status and trends of various kinds of aids for physically handicapped are at various stages of implementation.

Special attention is being given to ensure that benefits of technology diffuse more effectively to various sections of the community and backward areas of the country.

The expenditure on Science and Technology (1) during the years 1984-85 (proposed) is given below:

TABLE 2.

(in lakh of rupees)

	Plan	Non-Plan	Total
1983-84	7470.00	9773.67	17244.57
1984-85	9274.41	10683.00	19957.41

5. 'CLASS' - A CASE STUDY

An ambitious programme for introducing computer literacy as in intregal part of every child's eduction has been taken up by the Department of Electronics with full cooperation of the Ministry of Education on a national scale. This project called 'CLASS' (computer literacy and Studies of Schools) is felt to be integral and critical of India's development. It is the imperative of the information technology revolution, which is, silently perhaps, but most certainly sweeping the world. The new revolution is knowledge based; it is manpower intensive, it turns the burden of excess manpower into an asset for expansion. This time it is the microcomputers that are bringing the kind of revolution in the society as was witnessed when engineering got into business during the Industrial Revolution. Computer Literacy has the potential and urgency for the development of our country. Therefore, an essential part of the children's spectrum of educational skills must include familiarity with the use and application of computers.

The objectives of CLASS project are:

- to provide students with a broad under standing of computers and their use;
- to provide handsome experience;
- to familiarise the students with the range of computer applications in all walks of human activity and the computer's potential as a controlling and information processing tool; and,
- to demystify computers and to develop a degree of ease and familiarity with computers which would be conducive to developing individual creativity in identifying and developing applications relevant to their immediate environment.

With this in mind, computer education in schools and colleges has been introduced in a phased manner. A number of engineering institutions in the country have been identified, as resource centres having on an average 5-6 schools attached to them. Some 250 schools (Government, Government-aided and private schools) distributed geographically all over the country would be benefitted. The extension of this programme to other schools, and coverage in the seventh five-year plan would be decided after completion of this pilot project. The resource centres are supposed to provide functional support such as a computing system with related soft-ware and peripheral devices to the schools assigned to them; to conduct teachers' training programmes and to develop computer application software for them. The Departmwnt of Electronics has taken up the job of providing hardware and the relevant software to the schools. The curricula for both students' and teachers' training are ready and a text book based on it has been prepared by the National Council of Educational Research and Training (NCERT) in consultation with IIT, Delhi.

After establishing computer literacy programmes in schools, it is intended to use computers to improve the teaching of other subjects such as Physics. Mathematics, etc. This activity may be dependent on the availability of proper Computer Aided Learning (CAL) software. Programmes for the preparation of CAL software at the very first stage of the pilot project has been launched.

6. CONCLUSION

Thus, computers, relieving the mankind of mental drudgery, have brought about the second Industrial Revolution or the Scientific Revolution. The computer has become the most basic technological tool and fundamental to every kind of human endeavour. The launching of project 'CLASS' on a national scale has led to the firm belief that computer literacy will be as important as the three R's in the years to follow. The project has been started on a firm footing and promises to be the most challenging project in information technology. Though still in its infancy, the project holds high hopes for future developments in this area in India.

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A Study of a Coded 8PSK Modem with a Viterbi Decoder Using Simplified Metric Calculation

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1. Abstract

This paper addresses the problem of designing a simple Viterbi decoder for a coded octal phase-shift keying (8PSK) modem. It is important and often essential to simplify the process of metric calculation in a Viterbi decoder, since it realizes reduced hardware complexity and high-speed operation of the modem. An analytical expression is introduced for the performance of a coded 8PSK modem with such a Viterbi decoder, and is then applied to a typical coded 8PSK modem. It is shown that the modem can be designed with simple values of parameters with no significant performance degradation.

2. INTRODUCTION

In recent years, there has been increased interest in coded octal phase-shift keying (8PSK) modulation as a potential alternative to current quaternary phase-shift keying (QPSK) modulation in digital satellite communications. Conventional QPSK modems are to be replaced by coded 8PSK modems, when it is required to establish reliable communications either with small antennas or in such situations where carrier-to-noise ratio (CNR) is limited.

Forward error correction (FEC) coding and 8PSK modulation are combined as an entity in coded 8PSK modulation. An FEC coding with a convolutional code of rate 2/3 is employed at the transmit side, and the Viterbi decoding (1),(2) is performed at the receive side. Coded 8PSK modulation has an attractive property for satellite communications that low bit error rate (BER) is achieved without sacrificing bandwidth efficiency; it provides a significant coding gain relative to the performance of uncoded QPSK modulation, while it conveys two information bits per symbol, the same as for QPSK modulation.

A considerable approach is issued by Ungerboeck (3) on the code-design problem with signal sets expanded beyond two signals on one modulation dimension, and FEC codes are presented that are suitable for coded 8PSK modulation. Performance of 8PSK modulation is investigated by Rhodes, Lebowitz, Fang and Chang (4),(5), and the effects of imperfect carrier recovery on its performance is studied by Fujino, Umeda and Yamazaki (6). Related work is reported in (9)-(11).

This paper addresses the problem of designing a simple Viterbi decoder for a coded 8PSK modem (7). This problem is important and often essential, since the most critical unit in the modem is its Viterbi decoder with respect to the hardware complexity and the operating speed. Snyder (8) suggested a simple Viterbi decoder applicable to a coded 8PSK modem for 120 Mbit/s time-division multiple-access (TDMA) satellite communications. However, no quantitative study has so far been reported on this problem.

Two main types of simplifications are considered in this paper:

(a) Simplification of the process of branch metric calculation by assigning simple values to the components of reference signal in the branch metric calculator.
(b) Simplification of the process of comparison and selection of path metrics by allowing an uncertainty region in the characteristic of comparators in the add-compare-select (ACS) circuit.

These simplifications decrease the hardware complexity, and increase the operating speed of a coded 8PSK modem.

An analytical expression is introduced in this paper for the performance of a coded 8PSK modem with such a Viterbi decoder. The established approach to the evaluation of the BER performance of Viterbi decoding (1),(2) is extended here to include aspects of the simplifications. An additive white Gaussian noise (AWGN) channel is assumed, and the 8PSK modem itself is assumed to be an ideal one with infinitely fine soft decision function.

The analytical expression is easily applied to a variety of coded 8PSK modems, and allows a system designer to assess the tradeoffs involved in the simplifications. In this paper, it is applied to a typical coded 8PSK modem (8), which employs the Ungerboeck code of constraint length $\nu = 2$ (3). This type of coded 8PSK modem provides the asymptotic coding gain of 3 dB relative to the uncoded QPSK modem. The resulting BER performance shows that the simplifications can be introduced in the modem with no significant performance degradation.

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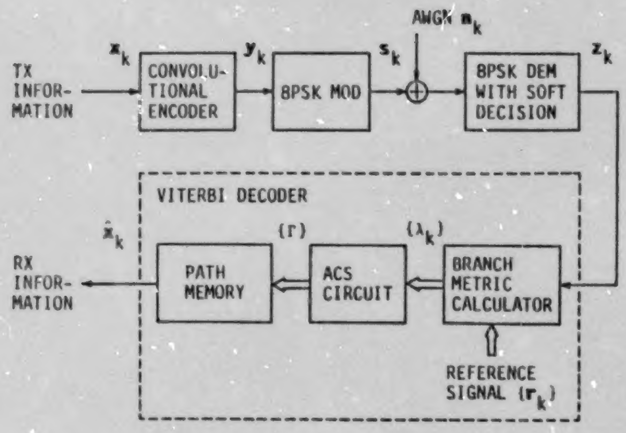
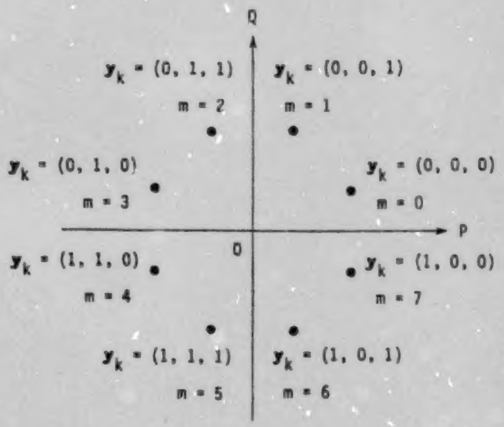
†This paper is based in part on work currently being performed under the sponsorship of the International Telecommunications Satellite Organization (INTELSAT). Any views expressed are not necessarily those of INTELSAT.



AWGN $\mathbf{n}_k$
TX INFORMATION
$\mathbf{x}_k$
CONVOLUTIONAL ENCODER
$\mathbf{y}_k$
8PSK MOD
$\mathbf{s}_k$
8PSK DEM WITH SOFT DECISION
$\mathbf{z}_k$
VITERBI DECODER
$\hat{\mathbf{x}}_k$
$\{\Gamma\}$
$\{\lambda_k\}$
RX INFORMATION
PATH MEMORY
ACS CIRCUIT
BRANCH METRIC CALCULATOR
REFERENCE SIGNAL $\{\mathbf{r}_k\}$

Figure 1. Block diagram of coded 8PSK modem.



Q
$\mathbf{y}_k$ = (0, 1, 1)
m = 2
$\mathbf{y}_k$ = (0, 0, 1)
m = 1
$\mathbf{y}_k$ = (0, 1, 0)
m = 3
$\mathbf{y}_k$ = (0, 0, 0)
m = 0
P
0
$\mathbf{y}_k$ = (1, 1, 0)
m = 4
$\mathbf{y}_k$ = (1, 0, 0)
m = 7
$\mathbf{y}_k$ = (1, 1, 1)
m = 5
$\mathbf{y}_k$ = (1, 0, 1)
m = 6

Figure 2. Gray mapping in 8PSK signal space.

3. ANALYSIS

A description of a coded 8PSK modem will be presented. Simplifications will be introduced in the process of metric calculation of the Viterbi decoder, and an analytical expression will be derived to upper bound the BER performance of the modem.

3.1 COMMUNICATION SYSTEM MODEL

Figure 1 is a block diagram of a coded 8PSK modem. The information symbol $\mathbf{x}_k$ is a pair of bits to be transmitted, and is input to the encoder for a convolutional code of rate 2/3. For each information symbol $\mathbf{x}_k$, a binary 3-tuple $\mathbf{y}_k$ is produced, which is then mapped into an octal symbol $\mathbf{m}$ for 8PSK signal generation. For Ungerboeck codes (3), a natural mapping is used, which is a straightforward mapping of binary words into octal values. However, for FEC codes with large minimum Hamming distances, a mapping, such as Gray mapping is used so that a large Hamming distance corresponds to a large Euclidean distance. Figure 2 illustrates Gray mapping in the 8PSK signal space.

Letting E_s denote the signal energy per 8PSK symbol, a transmitted 8PSK signal is

$$\mathbf{s}_k = \sqrt{E_s}\,\exp(j\theta_k) \tag{1}$$

where

$$\theta_k = \pi/8 + m\pi/4 \tag{2}$$

for m = 0, 1, ..., 7.

An AWGN channel is assumed, and $\mathbf{n}_k$ is zero-mean Gaussian noise with variance $N_0/2$. It is also assumed that the 8PSK modem itself is an ideal one with infinitely fine soft decision function. The received signal $\mathbf{z}_k = \mathbf{s}_k + \mathbf{n}_k$ is provided to the Viterbi decoder.

In the Viterbi decoder, a set of branch metrics $\{\lambda_k\}$ is generated at the branch metric calculator and is supplied to the ACS circuit. In the ACS circuit, branch metrics along various signal paths are added, and the results are compared and selected to produce a set of path metrics $\{\Gamma\}$. The decoded symbol $\hat{\mathbf{x}}_k$ is read out from the path memory by selecting the oldest symbol on the path having the maximum path metric, and the Viterbi decoding is accomplished.

3.2 BRANCH METRIC CALCULATION

A branch metric λ_k corresponds to the logarithm of the conditional probability density function for a branch, and is expressed by the inner product of the received signal and the reference signal for the branch:

$$\begin{aligned}\lambda_k &= (\mathbf{r}_k,\ \mathbf{z}_k)\\ &= r_k^{(P)} z_k^{(P)} + r_k^{(Q)} z_k^{(Q)}\end{aligned} \tag{3}$$

where $r_k^{(P)}$, $r_k^{(Q)}$, $z_k^{(P)}$ and $z_k^{(Q)}$ are components of the reference signal $\mathbf{r}_k$ and the received signal $\mathbf{z}_k$ in the two orthogonal channels P and Q. The two components of a reference signal can assume values of only ±a and ±b, where a and b correspond to $\cos(\pi/8)$ and $\sin(\pi/8)$, respectively. Each of the components assumes values of ±a and the other becomes ±b, depending on the branch being considered. The principle of branch metric calculation is depicted in Figure 3.

The process of branch metric calculation can be simplified by assigning some simple values to a and b. This type of simplification decreases the hardware complexity of the branch metric calculator and increases its operating speed. Also, it reduces the magnitude of a branch metric produced, and thereby increases the operating speed of adders in the ACS circuit.

A reference signal $\mathbf{r}_k$ is expressed as

$$\mathbf{r}_k = \sqrt{E_r}\,\exp(j\psi_k) \tag{4}$$

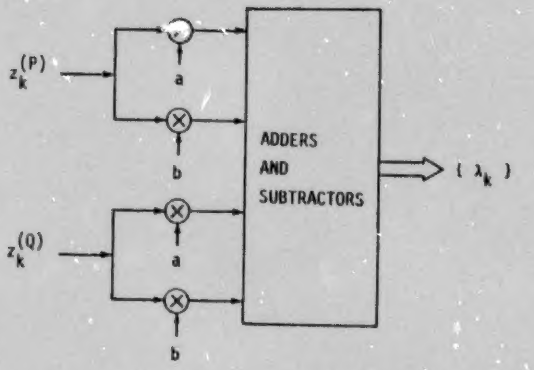


Figure 3. Block diagram of branch metric calculation.

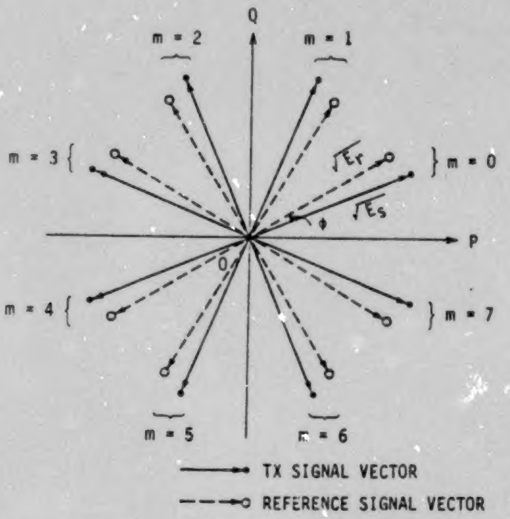


Figure 4. TX signal vectors and reference signal vectors in 8PSK signal space.

where $E_r = a^2 + b^2$, and

$$\psi_k = \frac{\pi}{8} + \frac{m\pi}{4} + (-1)^m\phi \tag{5}$$

for m = 0, 1, ..., 7, where the phase error

$$\phi = \tan^{-1}(b/a) - \pi/8 \tag{6}$$

is originated from inaccuracies in a and b. Figure 4 illustrates the relation between transmitted signal vectors and reference signal vectors in the 8PSK signal space. Without loss of generality, the magnitude of the phase error ϕ is assumed to be less than $\pi/8$.

3.3 PROPERTIES OF PATH METRIC

Let Γ be the metric of the correct path $\mathbf{s}$, and let Γ' be that of an incorrect path $\mathbf{s}'$, which differs from $\mathbf{s}$ in ℓ consecutive branches. Then the difference of the path metrics is written as

$$\Gamma - \Gamma' = \sum_{k=1}^{\ell}(\mathbf{r}_k - \mathbf{r}_k', \mathbf{z}_k) \tag{7}$$

where $\mathbf{r}_k$ and $\mathbf{r}_k'$ are the reference signal of the kth branch along the correct path $\mathbf{s}$ and that along the incorrect path $\mathbf{s}'$, respectively.

Since $\mathbf{z}_k$ is a Gaussian variable, $\Gamma - \Gamma'$ is also Gaussian, and its mean is given by

$$\mu = \sum_{k=1}^{\ell}(\mathbf{r}_k - \mathbf{r}_k', \mathbf{s}_k). \tag{8}$$

The relation between the phase of a reference signal and that of a transmitted signal is

$$\psi_k = \theta_k + \varepsilon_k\phi \tag{9}$$

where ε_k assumes values of ±1, depending on the phase of the transmitted signal:

$$\varepsilon_k = \begin{cases} 1, & \text{if } \theta_k = \pi/8 + n\pi/2 \\ -1, & \text{if } \theta_k = -\pi/8 + n\pi/2 \end{cases} \tag{10}$$

for n = 0, ..., 3. Using (9), the mean μ is expressed in terms of the phases of reference signals:

$$\mu = 2\sqrt{E_r E_s}\sum_{k=1}^{\ell}\{\sin^2\frac{\psi_k - \psi_k'}{2} - (\varepsilon_k/2)\sin(\psi_k - \psi_k')\tan\phi\}. \tag{11}$$

In a similar manner, the variance of $\Gamma - \Gamma'$ is found to be

$$\sigma^2 = 2E_r N_0 \sum_{k=1}^{\ell}\sin^2\frac{\psi_k - \psi_k'}{2}. \tag{12}$$

3.4 PAIRWISE ERROR PROBABILITY

A set of path lengths are compared in the ACS circuit to select the most probable path. The process of comparison and selection can be simplified, if an uncertainty region is allowed in the characteristic of comparators. This type of simplification decreases the hardware complexity, and increases the operating speed of the ACS circuit.

When the comparator with an uncertainty region of width $\Delta\Gamma$ is used to compare the path length Γ and Γ', the pairwise error probability that the incorrect path $\mathbf{s}'$ is selected instead of the correct path $\mathbf{s}$ is

$$\begin{aligned} P_E(\mathbf{s} \to \mathbf{s}') &= \Pr\{\Gamma - \Gamma' < -\Delta\Gamma/2\} + (1/2)\Pr\{|\Gamma - \Gamma'| \le \Delta\Gamma/2\} \\ &= (1/2)\{Q(\mu/\sigma - \Delta\Gamma/2\sigma) + Q(\mu/\sigma + \Delta\Gamma/2\sigma)\} \end{aligned} \tag{13}$$

where $Q(\beta)$ is the Gaussian integral function:

$$Q(\beta) = (1/\sqrt{2\pi})\int_{\beta}^{\infty} \exp(-x^2/2)dx. \tag{14}$$

Suppose that in the unmerged span of the paths there exist k_n pairs of branches for which the transmitted 8PSK signals $\mathbf{s}_k$ and $\mathbf{s}_k'$ have the phase difference of $|\theta_k - \theta_k'| = n\pi/4$ for $n = 1, \ldots, 4$. As shown in Appendix A, the formula:

$$Q(\sqrt{x + y}) \leqq Q(\sqrt{x}) \exp(-y/2) \quad x, y \geqq 0 \tag{15}$$

can be used to upper bound the pairwise error probability. The result is given by

$$\begin{aligned} &P_E(\mathbf{s} \rightarrow \mathbf{s}') \\ &\leqq Q(\sqrt{(E_b/N_0)D_{min}(\phi)} \cos\phi) \\ &\quad \cdot\exp(-(1/2)(E_b/N_0)\{D(\phi) - D_{min}(\phi)\}\cos^2\phi) \\ &\quad \cdot\cosh(\mu\Delta\Gamma/2\sigma^2) \end{aligned} \tag{16}$$

where E_b is the signal energy per information bit ($E_b = E_s/2$), and

$$D(\phi) = \sum_{n=1}^{4} \{k_n d_n^2(\phi) - \ell_n\delta_n(\phi)\} \tag{17}$$

where

$$\begin{aligned} d_1^2(\phi) &= 4\{\sin^2(\tfrac{\pi}{8} + \phi) - \sin(\tfrac{\pi}{4} + 2\phi)\tan\phi\} \\ d_2^2(\phi) &= 2 + 4\tan\phi \\ d_3^2(\phi) &= 4\{\sin^2(\tfrac{3\pi}{8} + \phi) - \sin(\tfrac{\pi}{4} - 2\phi)\tan\phi\} \\ d_4^2(\phi) &= 4 \\ \delta_1(\phi) &= \delta_3(\phi) = 4\sqrt{2} \sin^2\phi\tan\phi \\ \delta_2(\phi) &= 8\tan\phi \\ \delta_4(\phi) &= 0 \end{aligned} \tag{18}$$

and the constant ℓ_n depends on the phases of transmitted signals on the paths $\mathbf{s}$ and $\mathbf{s}'$, and lies in the range of $0 \leqq \ell_n \leqq k_n$ for $n = 1, 2, 3$. Furthermore, the function $D_{min}(\phi)$ in (16) is specified by the relation:

$$\begin{aligned} &(E_b/N_0)\{D(\phi) - D_{min}(\phi)\}\cos^2\phi \\ &\qquad - \mu\Delta\Gamma/\sigma^2 + (\Delta\Gamma/2\sigma)^2 \geqq 0. \end{aligned} \tag{19}$$

It is to be noted that, in the ideal case of $\phi = 0$, each $E_s d_n^2(\phi)$ reduces to the squared Euclidean distance between 8PSK signals: $4E_s\sin^2(n\pi/8)$ for $n = 1, \ldots, 4$, and $D(\phi)$ reduces to the squared Euclidean distance normalized by E_s between the paths $\mathbf{s}$ and $\mathbf{s}'$. Therefore, letting d_f denote the minimum free Euclidean distance of the FEC code employed, $D_{min}(\phi)$ reduces to

$$D_{min}(\phi) = d_f^2/E_s \tag{20}$$

in the ideal case of $\phi = 0$ and $\Delta\Gamma = 0$.

3.5 UPPER BOUND ON BER

A method is established (1),(2) to obtain a tight-upper bound on the BER performance of Viterbi decoding. In applying it here to the case of random data transmission in a coded 8PSK modem, care must be taken to include aspects of the simplifications. An upper bound on the BER for a particular path must be averaged over the ensemble of all possible correct paths, since the phase error ϕ can be either positive or negative, depending on the phase of the transmitted signal.

Denoting the ensemble average by $< \cdot >$, the BER is upper bounded by

$$P_b \leqq \frac{1}{2} \sum_{i=1}^{\infty} \sum_{\mathbf{k}} i a(\mathbf{k}, i)\langle P_E(\mathbf{s} \rightarrow \mathbf{s}')\rangle \tag{21}$$

where $\mathbf{k} = (k_1, k_2, k_3, k_4)$, and $a(\mathbf{k}, i)$ is the number of incorrect paths with i bit errors whose squared Euclidean distance from the correct path is specified by $E_s\Sigma_{n=1}^{4}k_n d_n^2(0)$.

It is shown in Appendix B that, in the case of random data transmission, the variable ℓ_n in (17) is in general an independent random variable with probability density function

$$p_n(\ell_n) = \frac{1}{2^{k_n}}\binom{k_n}{\ell_n} \tag{22}$$

for $\ell_n = 0, \ldots, k_n$ and $n = 1, 2, 3$. It follows directly from (16) that the average pairwise error probability is bounded by

$$\begin{aligned} &\langle P_E(\mathbf{s} \rightarrow \mathbf{s}')\rangle \\ &= \sum_{\ell_1=0}^{k_1} \sum_{\ell_2=0}^{k_2} \sum_{\ell_3=0}^{k_3} \prod_{n=1}^{3} p_n(\ell_n)P_E(\mathbf{s} \rightarrow \mathbf{s}') \\ &\leqq Q(\sqrt{(E_b/N_0)D_{min}(\phi)} \cos\phi) \\ &\quad \cdot\exp\left[\frac{E_b/N_0}{2}\{D_{min}(\phi) - \sum_{n=1}^{4} k_n \tilde{d}_n^2(\phi)\}\cos^2\phi\right] \\ &\quad \cdot \prod_{n=1}^{3} \cosh^{k_n}\left[\frac{E_b/N_0}{4} \delta_n(\phi)\cos^2\phi\right] \cosh(\mu\Delta\Gamma/2\sigma^2) \end{aligned} \tag{23}$$

where

$$\begin{aligned} \tilde{d}_n^2(\phi) &= d_n^2(\phi) - \delta_n(\phi)/2 \\ &= 4\sin^2(n\pi/8) - 2\sqrt{2} \sin(n\pi/2)\sin^2\phi \end{aligned} \tag{24}$$

for $n = 1, \ldots, 4$.

As shown in Appendix C, μ/σ^2 is upper bounded by

$$\mu/\sigma^2 \leqq 2(E_b/N_0)\lambda_{max}^{-1}\{\cos\phi + \sin|\phi|\cot(\frac{\pi}{8} - |\phi|)\} \quad (25)$$

where λ_{max} is the maximum branch metric in the noiseless case with $\phi = 0$:

$$\lambda_{max} = \sqrt{E_T E_S}. \quad (26)$$

Hence, an upper bound on the average pairwise error probability is given by (23) and (25).

For a convolutional code for 8PSK modulation, the augmented generating function is written as

$$T(\mathbf{D}, I) = \sum_{i=1}^{\infty} \sum_{\mathbf{k}} a(\mathbf{k}, i) I^i \prod_{n=1}^{4} D_n^{k_n} \quad (27)$$

where the exponents of I and D_n correspond, respectively, to the number of bit errors and the number of branches having the squared Euclidean distance of $E_s d_n^2(0)$. Using (21), (23) and (27), the upper bound on the BER is expressed as

$$P_b \leqq \frac{1}{2} Q(\sqrt{(E_b/N_0)D_{min}(\phi)} \cos\phi)$$
$$\cdot\exp(\frac{1}{2}(E_b/N_0)D_{min}(\phi)\cos^2\phi)\cosh(\mu\Delta\Gamma/2\sigma^2)$$
$$\cdot\frac{\partial T(\mathbf{D}, I)}{\partial I}\Bigg|_{\substack{I=1 \\ D_n=\exp(-\frac{1}{2}(E_b/N_0)\tilde{d}_n^2(\phi)\cos^2\phi) \\ \cdot\cosh(\frac{1}{4}(E_b/N_0)\delta_n(\phi)\cos^2\phi) \\ n=1, \ldots, 4.}} \quad (28)$$

Finally, it is to be noted that $D_{min}(\phi)$ in (20) can be used in the general case of $\phi \neq 0$, $\Delta\Gamma \neq 0$ to obtain an approximate upper bound on the BER. If the amounts of the simplifications: $|\phi|$ and $\Delta\Gamma$ are small, then the bound is close to the upper bound, since the relation:

$$Q(\sqrt{x + y}) \cong Q(\sqrt{x})\exp(- y/2) \quad (29)$$

holds for $x \geqq 0$ and $|y| \ll x$. The approximate upper bound is useful, since it makes it easy to evaluate the performance of a coded 8PSK modem.

4. NUMERICAL EXAMPLE

The analytical expression derived in the previous section will now be applied to a typical coded 8PSK modem (8) which employs the Ungerboeck code of constraint length $\nu = 2$ (3). Effects of the simplifications will be evaluated in terms of the BER performance.

4.1 THE STUDY CODE

Consider the Ungerboeck code of constraint length $\nu = 2$. The encoder is shown in Figure 5, and the augmented generating function is expanded as

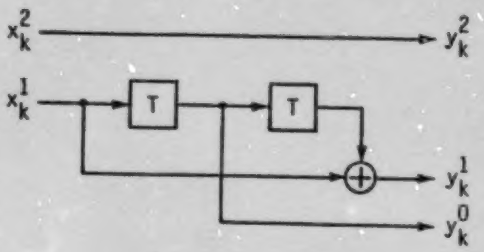


Figure 5. Convolutional encoder for Ungerboeck code of constraint length $\nu = 2$ (reproduced from (3)).

$$T(\mathbf{D}, I) = D_4 I + D_2^2(1 + I)^2 I \sum_{n=0}^{\infty}(1 + D_4 I)^n I^n U^{n+1}(\mathbf{D}, I) \quad (30)$$

where

$$U(\mathbf{D}, I) = D_1 + D_3 I + (D_1 I + D_3)^2 I \sum_{n=0}^{\infty}(D_1 + D_3 I)^n I^n. \quad (31)$$

Then it is seen from (30) and (31) that

$$D_{min}(\phi) = 4\mathrm{Min}\{1, 1 + \sin^2(\pi/8 - |\phi|) + \sin(\pi/4 - 2|\phi|)\tan|\phi| - 2\tan|\phi|\}$$
$$- 2(\Delta\Gamma/\lambda_{max})\sec\phi\{1 + \tan|\phi|\cot(\pi/8 - |\phi|)\} \quad (32)$$

satisfies (19).

4.2 BER PERFORMANCE

Three approaches are taken to evaluate the performance of the modem:

(a) Theoretical upper bound on the BER obtained by using (28) and (32).
(b) Theoretical value of approximate upper bound on the BER obtained by using (28) and (20).
(c) Approximate upper bound on the BER obtained by using (28) and (20) with the aid of a computer simulation.

In the computer simulation, a total of about 2,000 incorrect paths are generated, whose squared Euclidean distance d^2 from the correct path is specified by the relation: $d^2 \leqq 3d_f^2$. Values of $a(\mathbf{k}, i)$'s for these incorrect paths are used to obtain an approximate upper bound on the BER, since the BER is mostly determined by the incorrect paths whose Euclidean distances from the correct path are relatively small.

Effects of Phase Error of Reference Signal

Figure 6 shows the BER performance of the modem for three values of the magnitude of the phase error: $|\phi| = 0°$, $5°$ and $10°$. Figure 7 shows equivalent degradations in E_b/N_0 at BERs of 1×10^{-6} and 1×10^{-8}. It is seen in Figure 7 that

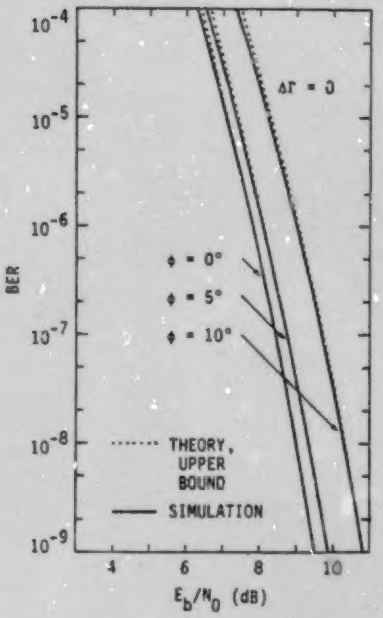


Figure 6. BER performance with phase error of reference signal.

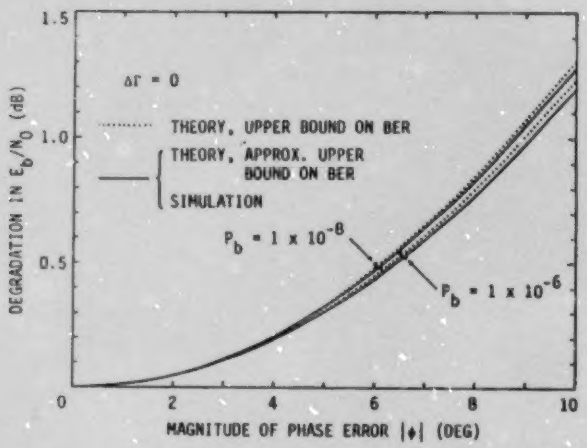


Figure 7. Equivalent degradation in E_b/N_0 due to phase error of reference signal.

the degradation is a small fraction of less than 0.1 dB, when the magnitude of the phase error is less than about 2.8°.

Effects of Uncertainty Region of Comparator

Figure 8 shows the BER performance of the modem for three values of the width of the uncertainty region: $\Delta\Gamma = 0$, $0.3\lambda_{max}$ and $0.5\lambda_{max}$. Figure 9 shows equivalent degradations in E_b/N_0 at BERs of 1×10^{-6} and 1×10^{-8}. It is seen in Figure 9 that the degradation is less than 0.1 dB, when the

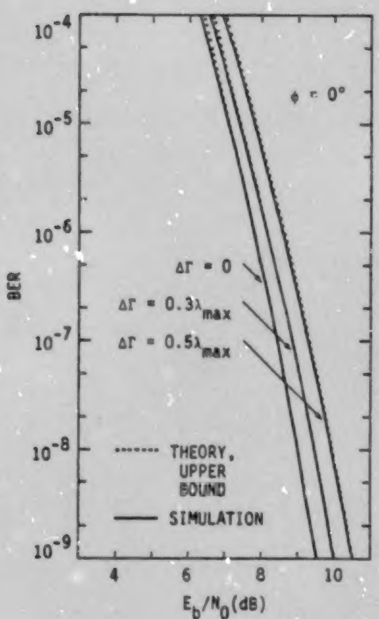


Figure 8. BER performance with uncertainty region of comparator.

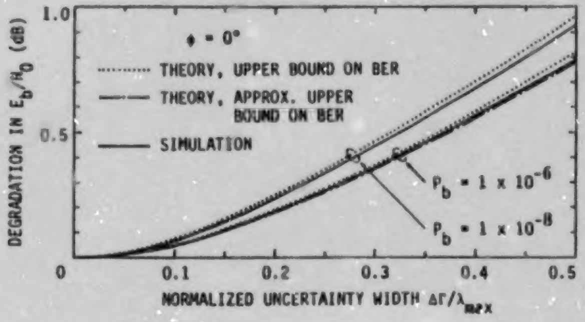


Figure 9. Equivalent degradation in E_b/N_0 due to uncertainty region of comparator.

width of the uncertainty region is less than about $0.1\lambda_{max}$.

Practical Considerations

In a practical coded 8PSK modem, some simple values will be assigned to the components a and b of the reference signals, and the modem suffers both the phase error of the reference signals and the uncertainly region of comparators. Figure 10 shows equivalent degradations in E_b/N_0 as a function of the width of the uncertainty region at a BER of 1×10^{-6} for (a, b) = (5, 2) and (2, 1). The ideal case of (a, b) = (cos(π/8), sin(π/8)) is also included in Figure 10.

The following points are obvious from Figure 10:

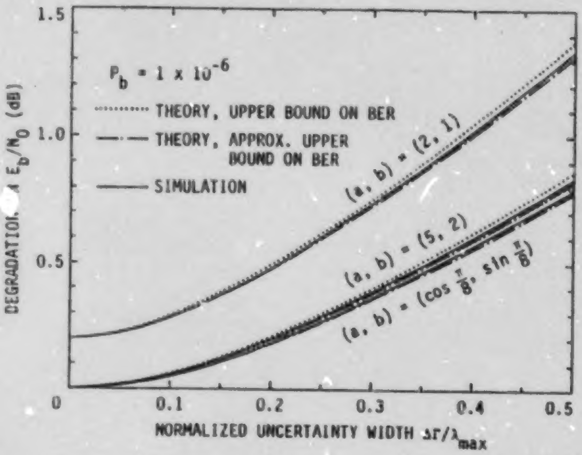


Figure 10. Equivalent degradation in E_b/N_0 due to uncertainty region of comparator as a function of values of components of reference signal.

(a) The pair of values: (a, b) = (5, 2) is a good practical choice in the sense that the degradation from the ideal case is negligibly small.

(b) Even the pair of simple values: (a, b) = (2, 1) causes only a small degradation of about 0.2 dB, when the width of the uncertainty region is negligibly small.

(c) In either case of (a, b) = (5, 2) or (2, 1), it is possible to allow the width of the uncertainty region of $0.1\lambda_{max}$ without introducing an increase in the degradation of more than 0.1 dB.

These results suggest that the modem can be designed using simple values of parameters with no significant performance degradation.

Finally, it is apparent in Figures 6 through 10 that the three approaches provide almost identical results from the practical viewpoint. Therefore, it is possible and also practical to calculate the approximate upper bound on the BER with the aid of a computer simulation to evaluate the performance of a coded 8PSK modem. This method can be easily applied to a variety of coded 8PSK modems, and is especially useful in the case of such a modem that employs an FEC code, for which tremendous calculation is required to find its generating function.

5. CONCLUSION

An analytical expression has been introduced for the BER performance of a coded 8PSK modem, in which the process of metric calculation in the Viterbi decoder is simplified. The expression obtained would allow a system designer to assess the tradeoffs involved in the simplifications.

A typical coded 8PSK modem employing the Ungerboeck code of constraint length $\nu = 2$ has been considered as an example, and the effects of the simplifications have been evaluated. It has been shown that the modem can be designed with simple values of parameters with no significant performance degradation.

The analytical expression can also be used with the aid of a computer simulation to calculate an approximate upper bound on the BER of such a coded 8PSK modem. Results in the example have shown that the approximate upper bound is close enough to the theoretical upper bound from the practical viewpoint. This method can be applied to a variety of coded 8PSK modems, and makes it easy to evaluate their performance. It will be especially useful in the case of such a modem that employs an FEC code, for which tremendous calculation is required to find its generating function.

APPENDIX A
UPPER BOUND ON PAIRWISE ERROR PROBABILITY

Using (11) and (12), a lower bound on μ^2/σ^2 is obtained:

$$\mu^2/\sigma^2 \geqq (E_b/N_0)D(\phi)\cos^2\phi \qquad (A.1)$$

where

$$D(\phi) = 4\sum_{k=1}^{\ell}\{\sin^2\frac{\psi_k - \psi'_k}{2} - \varepsilon_k\sin(\psi_k - \psi'_k)\tan\phi\} \qquad (A.2)$$

with equality if $\phi = 0$.

Suppose that in the unmerged span of the paths there exist k_n pairs of branches for which the transmitted 8PSK signals $\mathbf{s}_k$ and $\mathbf{s}'_k$ have the phase difference of $|\theta_k - \theta'_k| = n\pi/4$ for $n = 1, \ldots, 4$. Also suppose that there exist among them ℓ_1 pairs of branches for which $\varepsilon_k(\theta_k - \theta'_k) = -\pi/4$, ℓ_2 pairs of branches for which $\varepsilon_k(\theta_k - \theta'_k) = \pi/2$ and ℓ_3 pairs of branches for which $\varepsilon_k(\theta_k - \theta'_k) = -3\pi/4$. Then $D(\phi)$ in (A.2) reduces to (17).

From (A.1), the relation:

$$Q(\mu/\sigma \pm \Delta\Gamma/2\sigma)$$
$$\leqq Q(\sqrt{(E_b/N_0)D_{min}(\phi)\cos^2\phi + h^{(\pm)}(\phi)}) \qquad (A.3)$$

is obtained, where

$$h^{(\pm)}(\phi) = (E_b/N_0)\{D(\phi) - D_{min}(\phi)\}\cos^2\phi$$
$$\pm \mu\Delta\Gamma/\sigma^2 + (\Delta\Gamma/2\sigma)^2. \qquad (A.4)$$

If $D_{min}(\phi)$ satisfies (19), then both $h^{(+)}(\phi)$ and $h^{(-)}(\phi)$ are positive functions, and the relation (15) can be applied to (A.3) to obtain

$$Q(\mu/\sigma \pm \Delta\Gamma/2\sigma)$$

$$\leqq Q(\sqrt{(E_b/N_0)D_{\min}(\phi)}\cos\phi)\exp\{h^{(\pm)}(\phi)/2\} \quad \text{(A.5)}$$

Substitution of (A.5) into (13) yields the desired relation (16).

APPENDIX B
PROBABILITY DENSITY FUNCTION OF VARIABLE ℓ_n

Consider the case of random data transmission, in which each element of the information symbol $\mathbf{x}_k$ is an independent random variable which assumes 0 or 1 with equal probability. The symbol $\mathbf{x}_k$ is encoded into a binary 3-tuple $\mathbf{y}_k$, which is then mapped into an octal symbol m.

Letting m^0 denote the least significant bit of the binary representation of m, it is in general expressed by a modulo-2 sum of elements of $\mathbf{y}_k = (y_k^2, y_k^1, y_k^0)$. For example,

$$m^0 = \begin{cases} y_k^0, & \text{for natural mapping} \\ y_k^2 \oplus y_k^1 \oplus y_k^0, & \text{for Gray mapping.} \end{cases} \quad \text{(B.1)}$$

Furthermore, each element of $\mathbf{y}_k$ is a certain modulo-2 sum of the elements of $\mathbf{x}_k$'s. Hence, for any nontrivial FEC code, m^0 is generally expressed by a modulo-2 sum of elements of $\mathbf{x}_k$'s, and is, therefore, an independent random variable which assumes 0 or 1 with equal probability. This result indicates that ε_k in (10) is also an independent random variable which takes on 1 or -1 with equal probability. Accordingly, the variable ℓ_n (n = 1, 2, 3) introduced in Appendix A is a random variable with binomial distribution whose probability density function is given by (22).

APPENDIX C
UPPER BOUND ON μ/σ^2

Using (11) and (12), an upper bound on μ/σ^2 is obtained:

$$\mu/\sigma^2 \leqq \sqrt{E_s/E_r}N_0^{-1}\cos\phi\{1 + g(\phi)/2\} \quad \text{(C.1)}$$

where

$$g(\phi) = \frac{\sum_{k=1}^{\ell} |\sin(\psi_k - \psi_k')\tan\phi|}{\sum_{k=1}^{\ell} \sin^2\{(\psi_k - \psi_k')/2\}} \quad \text{(C.2)}$$

with equality if $\phi = 0$. It is seen that the relation

$$|\sin(\psi_k - \psi_k')|$$

$$\leqq 2\cot(\pi/8 - |\phi|)\sin^2\{(\psi_k - \psi_k')/2\} \quad \text{(C.3)}$$

holds for all possible values of $\psi_k - \psi_k'$. Substitution of (C.2) and (C.3) into (C.1) yields the desired relation (25).

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STORE AND FORWARD TRUNK SWITCHING

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1. Abstract

The Store and Forward Switching System is designed to automatize operator positions in Manual Trunk Exchanges. The traditional method of ticket preparation is computerised and here all operator positions are provided with VDUs and keyboards. Main asset of this system is the flexibility achieved from identical operator positions; type, group and traffic assignments can be changed by commands. Operations are cordless. The work stations is designed with human engineering and ergonomic principles in mind to provide simple and efficient work stations.

2.0 INTRODUCTION:

Even with rapid evolution of sophisticated telecommunication networks, with direct subscriber dialled facilities the need still remains for traditional operator assistance which has motivated the development of "SFK" (Store and Forward Trunk Switching System).

The services which justify operator assistance are,

- calls to destinations which cannot be directly dialled.
- person-to-person calls, demand calls, language assistance, customer data services etc.,

The SFK system is the operator services capability of a transit exchange which is undergoing extensive field trials in Indian P&T networks.

3.0 SYSTEM ARCHITECTURE:

3.1 Concept:

The system architecture is shown in Fig.1. The SFK is an integrated system consisting of an Electronic Transit Trunk Exchange to which many manual trunk exchanges are connected and a Store and Forward unit which stores the call details, performes automatic call queuing , call distribution and forwards the call to the operator's when trunk circuits are free. Basically SFK forms the nucleaus around which several manual trunk exchanges are connected. Each manual exchange is provided with large number of operator positions. These operator positions are controlled by OPERATOR POSITION CONTROLLER(OPC).

The concept of using a ticket for gathering booking information is still retained but traditional paper tickets is replaced by a computerised ticket stored in the system memory. The system fully exploits the advantages of distributed processor control and hence many of the routine tasks performed by operator in a manual system can be performed automatically to improve the operator efficiency.

3.2 FEATURES OF THE SYSTEM:

The prominent features of the system are:

- Visual display unit with keyboards for cordless operation of the operators.
- The flexibility to assign a position either for booking or for trunk operator position by commands.
- Supporting data like routing information, customer data service information and directory enquiry can be accessed easily.
- Flexible call distribution.
- Improved Call handling capacity and better service to customers.

4.0 SUB SYSTEM:

Major sub systems of SFK are STORE AND FORWARD UNIT(SFU), ELECTRONIC TRANSIT EXCHANGE(ETX)and OPERATOR POSITION CONTROLLER(OPC).

4.1.0 STORE AND FORWARD UNIT:(SFU)

The Stored Program Control nature of SFU and its integration into transit exchange contributes to system efficiency

Store and Forward Unit accepts all information from various manual trunk exchanges and stores them route wise and in the order of priority. Next the call is forwarded to the Switching Unit which will check the trunk availability and informs the SFU accordingly. The SFU routes the call to one of the free operators.

4.1.1 CALL QUEUES:

The main function of SFU is call distribution. For each incoming call the call distributor has to create a call ticket and inserts into a queue wherein the ticket number is assigned to a free operator in the order of priority. For some reason if the call setup is not possible the function of entering the call ticket in delayed or deferred call queue is also the job of the call distribution system.

There are three types of call queues incoming calls,demand calls and calls which are to be retried. In addition the queueing structure should also take care of delayed calls, deferred calls, transferred calls and operator group queues. The call queue system is shown in Fig.2.

4.2.0 OPERATOR POSITION CONTROLLER(OPC):

Each manual trunk exchange will have a operation position controller. The function of the controller is threefold. The first is controlling eight operator positions. The second is handling the data communications between the operator position and store and forward unit for call set up. The third function is that it provides a switch for cordless operation. The controller is microprocessor based and the block diagram is shown in Fig.3.

4.2.1 BOOKING OPERATOR POSITION:

All the operator positions are alike and they can be assigned as booking position or trunk operator position by giving suitable commands.

When a call is booked, the ticket will be displayed on VDUs screen. Control keys are provided to control the cursor position and booking details are entered by the booking operator. Full editing features for control of cursor position, insertion and deletion of characters are provided. Alpha numeric keyboard is provided to enter any information. After entering the information the system responds with a ticket number which will be communicated to the subscriber.

4.2.2 COMMUNICATION WITH SFU:

The booking information from each terminal is communicated to the store and forward unit, where it will be stored in the order of priority. The information is transmitted on the same trunk circuits which carry voice by using frequency shift keying at 300 bauds. The data will be transmitted when the trunk is idle or as soon as it becomes free.

4.2.3 TRUNK OPERATOR POSITION:

When the call is offered to the trunk operator, the full ticket details are displayed on screen as the trunk operator was unaware of the existence of such a call. The trunk operator then setsup the call by first contacting the distant exchange by pressing 'Dial Trunk' key. After establishing the contact, she will get the local subscriber by pressing 'Dial Local' key. Operator will then establish the call by pressing'Connect'key. The metering of the call will start from this time. In case, the operator is unable to establish the call due to any of the various reasons like called number busy or person for whom the call is booked, in person to person call, she will press 'Retry' key. The call will be retried after about twenty minutes.

4.2.4 SWITCH:

Present manual trunk exchanges uses cords for setting up of a call. This is a tedious procedure and the quality of speech depends on the cord circuit. To avoid these problems an Electronic Space Switch is provided. This has capability of connecting eight operators with eight SFK junctions or eight local junctions.

4.3 TRANSIT SWITCH(ETX):

The manual trunk telephone service has many drawbacks which result in heavy delays and high percentage of ineffective calls. These delays are due to the necessity to 'Transit' the trunk calls through one or more trunk exchanges.

The store and forward trunk switching is the solution to avoid setting up of trunk calls from individual operators and the Electronic Transit Exchange does the switching of the calls. Some features of the transit switch are:

- PAM TDM based. Since a completely digital system will be effective only with long distance digital channels, with majority of network channels being analogue a digital exchange would introduce quantization noise because of several coding and decoding stages. The end to end losses would also be high.

- The exchange uses Z80 microprocessor
- Self sufficient diagnostic capability.
- Journalizing of the traffic to print out number of call attempts, number of effective calls, utilization time, count of a number of times wanted direction was busy etc.,

5.0 DESIGN CONSIDERATIONS AND ADMINISTRATIVE REQUIREMENT:

The extreme situation wherein the rate of incoming calls is very much higher than the rate of clearance of calls, a very important parameters which should be taken care of during design stage. Particular attention for the memory capacity is necessary. In such a situation which should not occur frequently the system has to identify the routes on which such congestion has taken place and a supervisory alarm is provided.

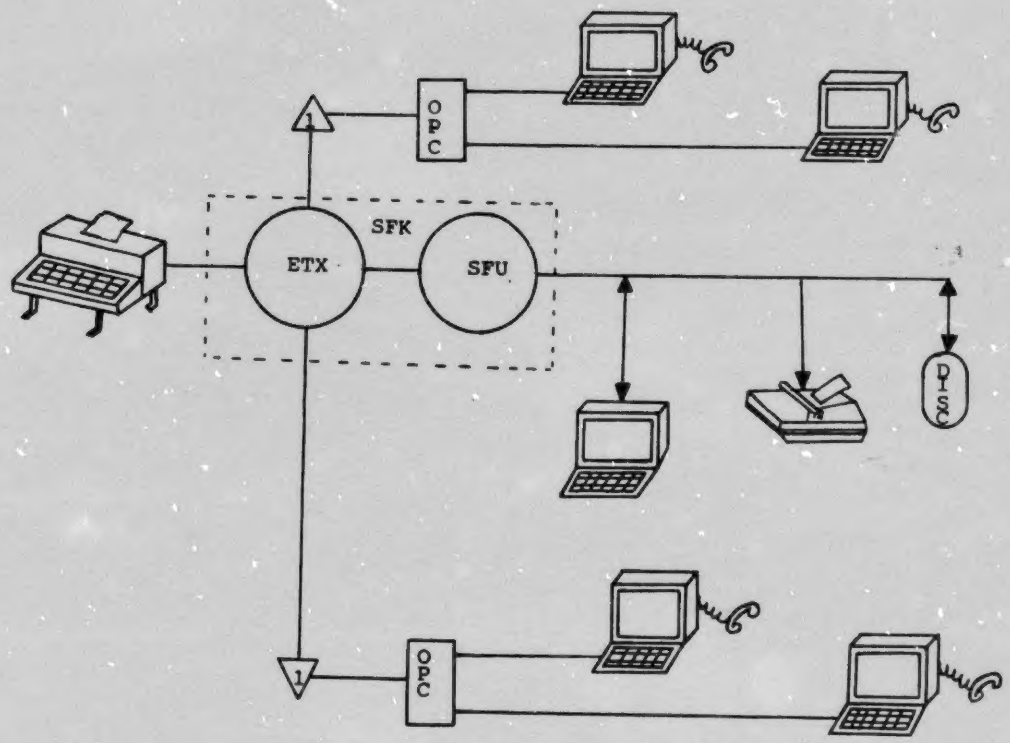

FIG.1

1 : Manual Trunk Exchange
SFU : Store and Forward Unit
ETX : Electronic Transit Exchange
SFK : Store and Forward Trunk
OPC : Operator Position Controller

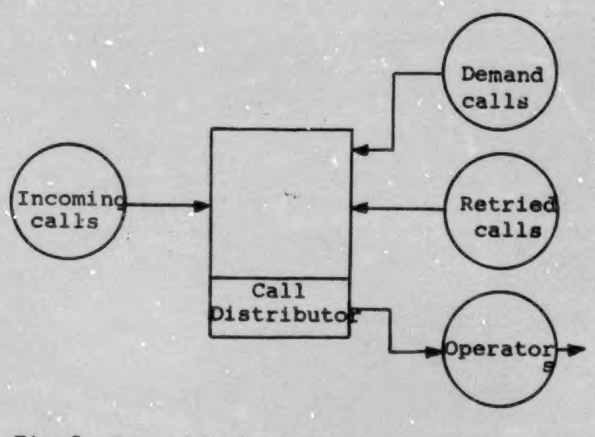
Demand calls
Incoming calls
Retried calls
Call Distributor
Operators

Fig.2: Queueing System

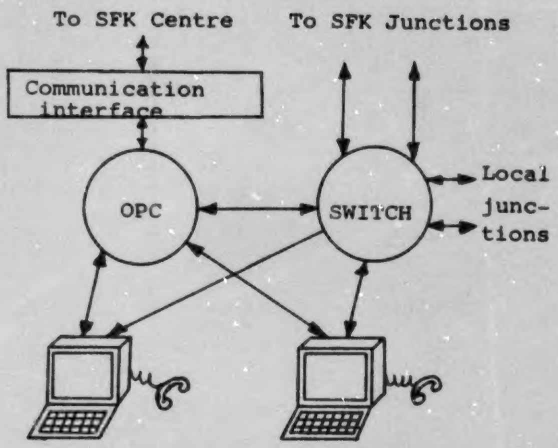
To SFK Centre
To SFK Junctions
Communication interface
OPC
SWITCH
Local junctions

Fig.3 : Operator Position Controller

The alarm is energised even when the memory is 80% full. Automatic dump retrieval from the bulk store is provided. Broadcast facility to all the booking stations to stop booking of calls under high congestion condition is necessary. This situation may arise for some routes and the system should monitor and keep the balance till the situation improves.

The supervisory console at the SFK centre displays status of the system, memory capacity left, inter-SFK conditions, the number of tickets in dump, total number of calls booked everyday, cleared and pending.

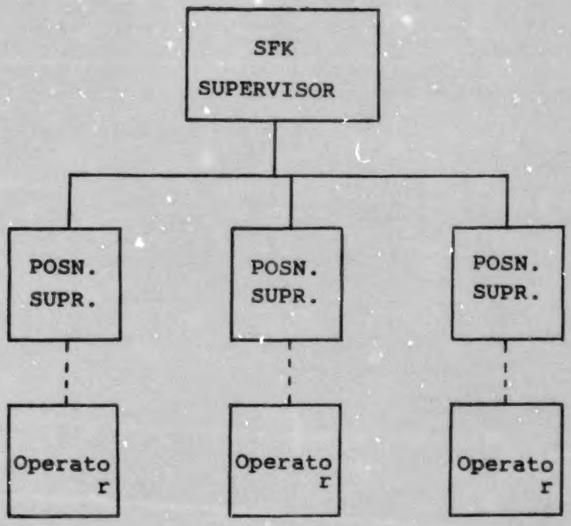
SFK SUPERVISOR
POSN. SUPR.
POSN. SUPR.
POSN. SUPR.
Operator
Operator
Operator

Fig.4 : Administrative Functions

The position supervisor can also monitor queueing delays, number of calls completed, released and delayed. Fig.4 depicts the scheme of administrative functions.

6.0 CONCLUSION:

The Store and Forward Trunk Switching eliminates the routine task of operators and improves their efficiency, there by giving a better customer service. Apart from efficiency, flexibility is a main asset of this integrated system. Operator positions can be located either near the exchange or in a remote location. Hence, the telephone administration can take the advantage of a distributed operator work force.

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ANALYSIS OF INTERMODULATION NOISE DUE TO HARMONIC TRANSMISSION IN PSK COMMUNICATION SYSTEM USING TWT AMPLIFIER

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ABSTRACT

For a PSK Communication System, an expression for intermodulation noise produced due to harmonic transmission has been derived. the phase distortion has been calculated. The intermodulation products have been expressed in terms of input harmonic levels and the channel characteristics and finally the intermodulation noise has been calculated.

INTRODUCTION

In a PSK Communication System, it is necessary to consider distortion due to variations in phase characteristics with the amplitude of signal, in addition to the distortion from the non-linearity in amplitude characteristics. These variations give rise to unwanted phase conversion and to resultant intermodulation distortion. The phase modulated harmonics of the carrier are proportional to the order of the harmonics. The phase modulated carrier passes through the channel which produces distortion in the harmonic modulation. The distorted harmonic modulation passes through TWT amplifier. The non-linearities in the TWT amplifier produce intermodulation due to harmonic transmission. We proceed to discuss:

(i) Channel Distortion
(ii) TWT - remodulation
(iii) Intermodulation due to harmonic transmission

(i) CHANNEL DISTORTION

A complex modulated wave form with carriers $k\omega_0$ having both amplitude and phase modulation $\alpha_k(t)$ and $\phi_k(t)$ can be written as:

$$V(t) = \sum_k Re\, V_k\left[1+\alpha_k(t)\right] exp\, j\left[k\omega_0 - \phi_k(t)\right]$$
$$= \sum_k Re\, V_k\left[1+p_k(t)-j\,q_k(t)\right] exp\, j\,k\omega_0 t \qquad (1)$$

where $p_k(t)$ and $q_k(t)$ are the quadrature modulation components of the harmonic carrier $k\omega_0$, eq. (3) defines a non-linear transformation T, relating two dimension vector (p_k, q_k) and $\alpha_k, \phi_k)$, to calculate the second and higher order distortion terms, such a cubic polynomial approximation of T will be as follows:

$$\begin{bmatrix} p_k \\ q_k \end{bmatrix} = T\begin{bmatrix} \alpha_k \\ \phi_k \end{bmatrix} = \begin{bmatrix} \alpha_k - \frac{\phi_k^2}{2} - \alpha_k \frac{\phi_k^2}{2} \\ \phi_k + \alpha_k \phi_k - \frac{\phi_k^3}{6} \end{bmatrix} \qquad (2)$$

and T^{-1} can be written as

$$\begin{bmatrix} \alpha_k \\ \phi_k \end{bmatrix} = T^{-1}\begin{bmatrix} p_k \\ q_k \end{bmatrix} = \begin{bmatrix} p_k + \frac{q_k^2}{2} - p_k \frac{q_k}{2} \\ q_k - p_k q_k + p_k^2 q_k - \frac{q_k^3}{3} \end{bmatrix} \qquad (3)$$

For the assumed linear channel the output and input quadrature modulation, components are linearly related by an index dependent on the channel characteristics

$$\begin{bmatrix} p_{lk} \\ q_{lk} \end{bmatrix} = L_k(s)\begin{bmatrix} p_{Hk} \\ q_{Hk} \end{bmatrix} = \begin{bmatrix} 1+D_k(s) & C_k(s) \\ -C_k(s) & 1+D_k(s) \end{bmatrix}\begin{bmatrix} p_{Hk} \\ q_{Hk} \end{bmatrix} \qquad (4)$$

$D_k(s)$
$C_k(s)$ are given characteristics

Eq.(4) is valid for the carrier i.e. m=1 as well as for harmonic modulation components (m≠1)

For no distortion

$D_1(s) = 0$

$C_1(s) = 0$

Carrier modulation transfer is symbolized by a unity matrix

$L_1(s) = U$

The non-linear distortion and conversion of the harmonic phase modulation components can be calculated by transfering the quadrature component of Eq.(2) applying linear transformation of Eq.(4) and recovering the output amplitude and phase modulation term form by using Eq.(3). The result can be written as the sum of the undistorted phase modulation products denoted by α_{Lk} and χ_{Lk}

$$\begin{bmatrix} \alpha_{Lk} \\ \phi_{Lk} \end{bmatrix} = \begin{bmatrix} 0 \\ k\phi \end{bmatrix} + \begin{bmatrix} \alpha_{Lk} \\ \chi_{Lk} \end{bmatrix} = \left[\, T^{-1} L_k(s)\, T \,\right]\begin{bmatrix} 0 \\ k\phi \end{bmatrix} \cdots\cdots (5)$$

The frequency dependent non-linear transformation expressed by operator product $T^{-1}L_k(s)T$ given the intermodulation caused by non-linearity of channel characteristics.

(ii) REMODULATION IN TWT

At the input of the TWT, the carrier with undistorted phase modulation and set of phase modulated harmonics with amplification and phase distortion are present. To calculate the response of TWT, we assume

(a) Slow variation of modulation components

(b) Harmonic amplitudes are much smaller than the carrier

By doing mathematical operation, the harmonic terms can be calculated by first order perturbation and the output terms can be written in the perturbational forms. The input and output perturbations are related by a linear convolution and is periodic in first variables due to experimental excitation. The periodic response can be expanded in Fourier Series.

It is shown that the output amplitude and phase modulation are proportional to $\eta_{\alpha k}$, $\eta_{\phi k}$, respectively.

It is interesting to note that for ideal limiter $\eta_{\alpha k} = 0$ and $\eta_{\phi k} = 1$.

(iii) INTERMODULATION DUE TO HARMONIC TRANSMISSION

The harmonic modulation transformation in the channel and TWT have been determined in Eqs. 6 and 7.

$$\begin{bmatrix}\alpha_{Lk}\\ \phi_{Lk}\end{bmatrix} = \begin{bmatrix}0\\ k\phi\end{bmatrix} + \begin{bmatrix}\alpha_{Lk}\\ \chi_{Lk}\end{bmatrix} = \left[\,T^{-1} L_k(s)\, T\,\right]\begin{bmatrix}0\\ k\phi\end{bmatrix} \qquad (6)$$

and

$$\begin{bmatrix}\alpha_{N1}\\ \chi_{N1}\end{bmatrix} = \sum_{k\neq 1}\left|\begin{matrix}V_{Lk}\\ V_{L1}\end{matrix}\right| \eta_k\, \theta_k \begin{bmatrix}\alpha_{Lk}\\ \chi_{Lk}\end{bmatrix} \qquad (7)$$

By successive application of these transmissions, the output modulation distortion resulting from the harmonic transmission can be expressed as

$$\begin{bmatrix}\alpha_{N1}\\ \chi_{N1}\end{bmatrix} = \sum_{k\neq 1}\begin{bmatrix}V_{Lk}\\ V_{L1}\end{bmatrix} \eta_k\, \theta_k \begin{bmatrix}T^{-1} L_k(s)\, T\\ -U\end{bmatrix} k \begin{bmatrix}0\\ \phi\end{bmatrix} \qquad (8)$$

The phase modulation distortion is given by second row of the matrix relations for intermodulation noise computation. The second and third distortion terms of the output phase modulation, denoted by $X_{N1}(2)$ and $X_{N1}(3)$ are sufficient.

$$\chi_{N1}(2) = \sum_{k\neq 1}\left|\frac{V_{Lk}}{V_{L1}}\right| \eta_{\phi k}\, \frac{k^2}{2}\left[\hat{C}(\phi^2) - 2\phi\,\hat{C}(\phi)\right]$$

$$\chi_{N1}(3) = \sum_{k\neq 1}\left|\frac{V_{Lk}}{V_{L1}}\right| \eta_{\phi k}\, \frac{k^3}{6}\left[\hat{D}(\phi^3) - 3\phi\,\hat{D}(\phi^2) + 3\phi^2\hat{D}(\phi)\right]$$

$$D(s) + jC(s) = \exp(I\,j\theta)\left[\hat{D}(s) + j\,\hat{C}(s)\right] \qquad (9)$$

The equation for $X_{N1}(2)$ and $X_{N1}(3)$, the intermodulation products have been expressed in terms of the input harmonic level, the modulation transfer parameters and channel characteristics.

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AUTOMATIC HIGH-FREQUENCY RADIO MESSAGE TERMINAL SYSTEM FOR SPARSELY POPULATED COMMUNITIES

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1. ABSTRACT

A message terminal to be used by remote communities is designed to augment the capabilities of existing High-Frequency radios by allowing transmission of text messages. It has been demonstrated that message communication was performed when radio conditions did not permit intelligible voice transmission. The terminal has an automatic frequency selection feature to increase the system reliability. The system does not require radio operators and is easily used by non-technical users.

The terminal network can be enhanced by a system controller to provide HF radio discipline to minimize collisions between stations and to overlay an electronic mail facility.

2. INTRODUCTION

An electronic mail facility is central to the creation of a versatile, inexpensive, automated HF radio network. Such a network permits the reliable exchange of messages between remote villages, installations, depots, ocean vessels, urban headquarters and offices. These facilities will be welcomed by many companies, organizations, and government departments which are unable to communicate by telephone, and for which satellite communication is an expensive alternative to cheaper but less reliable HF voice radio systems.

The HF network discussed in this paper is based on an HF Mini Terminal developed by Department of Communications and manufactured by a commercial company (1). The hardware environment of the electronic mail system is an 8088-based personal computer which is equipped with two 320K floppy disk drives and up to eight RS-232 serial ports and 256K bytes of RAM storage. One of the serial ports is dedicated for the control and data transfer function of the HF Mini Terminal. The rest of the serial ports are available for connection to auto-answer telephone modems or ASCII terminals. With the microcomputer keyboard and display, the system can provide eight simultaneous work stations for each microcomputer location. At least one microcomputer system per network is needed to exert system discipline and permit efficient use of the radio frequencies assigned to the network.

The QNX multitasking operating system has been chosen as the operating system for the microcomputer. QNX is a multitasking, multi-user, real-time operating system, which implements and optimizes the most important features of the well known AT&T UNIX operating system. The standard features of this operating system which provide the framework of the electronic mail software are: hierarchical file structure, secure file access by individual users without seeing the other users' files, powerful file manipulation utilities and serial communication support for remote users and file transfer functions.

2.1 HF MINI TERMINAL

The HF Mini Terminal is a self contained message terminal incorporating a special HF modem, a 20 character LED display, a small internal printer, and one RS-232 serial port for remote control by other data sources. The technical details of the terminal are given in (1). The HF modem consists of two independent synchronous FSK modems each carrying 100 bps. The FSK tones were centred at 700 and 1700 Hz in a standard 3000 Hz voice band channel. A frequency shift of ± 85 Hz was used to designate mark and space. Dual diversity is used to minimize the disruptive effects of selective fading. The information transfer is accomplished within an ARQ (automatic request for retransmission) packet radio protocol specifically designed to provide reliable data transmission in the HF propagation environment using a simplex SSB channel for transmit and receive. Message transmission is initiated with a "handshake" in which the stations exchange information on the call numbers and the length of the message. This procedure allows the terminal to perform a selective call to a particular destination. The information is protected with error detection codes to ensure that errors are detected with high probability and corrected by a selective repeat protocol. The undetected error probability is calculated to be 1 in 100 million characters.

The maximum number of characters that can be transmitted in one message is limited by the available memory size to 1280 characters. The Mini Terminal has two independent message buffers: one buffer is for outgoing messages and the other is for received messages. Both buffers hold the last message and to avoid the loss of received information the message is automatically printed. The terminal software performs one function at a time; thus when the user is typing a message the unit is not capable of answering any call request that may be received.

The Mini Terminal is designed for unattended message reception. It can be made to continuously scan the assigned channels in the receive mode. When there is traffic to be sent the originating terminal will transmit the handshake signal in each of the channels in turn, changing channels at a rate different from the scanning rate of the receiver. This difference in scanning rate allows the transmitter and receiver eventually to meet on every channel, thereby allowing the system to change frequency to match changing propagation conditions. This feature is important for a network of stations with widely different path lengths, requiring a number of frequencies to be used to obtain optimal performance.

2.2 NETWORK OPERATION OF HF TERMINALS

The Mini Terminals can operate in a stand alone configuration if the number of stations is about 5 or less and the message traffic is evenly distributed, but when the traffic reaches peak conditions the random access channel will be blocked. A communication controller which can distribute the message traffic peak by queuing the messages can improve the system throughput. The unpredictable nature of HF channel conditions may also require repeated calls to be made to the destination terminal by the message originator. Message store and forward, network management and simultaneous user access functions can be performed by an add-on external system in order to enhance the system performance.

The HF network control functions for the Mini Terminals are integrated into an electronic mail software program to provide many services and networking features that the Mini Terminal can not provide.

A typical configuration may consist of a radio station equipped with a HF Mini Terminal and a controller installed near a urban area. Several terminals and radio pairs serving widely separated remote areas forms the network. Users in the urban area can access the controller by dialing the telephone number of an auto-answer modem and input the message with an ASCII terminal to be forwarded to the remote terminal station. Messages from the remote areas are stored or delivered by the public switched telephone network. Figure 1 shows a typical installation of a HF terminal network.

3. ELECTRONIC MAIL FACILITY WITH HF TERMINALS

The term electronic mail covers a number of functions and in the context of this paper can be divided into two areas: electronic mail software that is installed in a computer, and the HF message transport function which is performed by the HF Mini Terminal system. This electronic mail system is a stand-alone network and does not depend on the facilities of any common carrier.

The electronic mail system is designed to operate with the HF Mini Terminal in the base station of a communication network linking remote areas with a population centre. It also provides an interface between the switched telephone system and the base station equipment, permitting one radio station and one antenna to be shared by many users. Messages for the remote stations are entered in a queue in the microcomputer to be delivered by the HF Mini Terminal. Incoming messages from the remotes addressed to the users are left in the microcomputer store to be read by the users.

3.1 SYSTEM BREAKDOWN

The electronic mail system will be described by the four essential components of the software. These are the users, the operator, the Mini Terminal interface, and the electronic mail system handler.

3.1.1 USERS

The users of the system that are connected to the microcomputer via local CRT terminals, or in the case of a remote user via a telephone line modem, and have the following functions available from the system.

(a) System logon with a personal password to prevent unauthorized entry into the system.

(b) Read the list of received messages, read a received message, get the list of the outgoing messages, and read an outgoing message.

(c) Write or edit an outgoing message.

(d) Send the created message from the outgoing message list.

(e) Cancel an outgoing or received message.

(f) Get directory of system users. The correspondence addressing of the messages are addressed by names plus optional location information.

(g) Get on-line help regarding the system commands.

The system can handle all the users and manage the Mini Terminal function concurrently without apparent slowdown of the system functions.

3.1.2 THE OPERATOR

The operator is classed as a super user with additional functions available to him. He has the following capabilities on the electronic mail system:

(a) Directory maintenance, adding or deleting users to the system.

(b) Modification of system parameters such as auto-delete time for read or unread messages, auto-delete time for sent messages.

(c) Auto-logoff time for inactive users to prevent the users keeping telephone lines busy.

(d) Modification of Mini Terminal message transmission schedule.

(e) Suspension of message transmission from the queue and provision for real-time control of the Mini Terminal.

3.1.3 HF MINI TERMINAL INTERFACE

The interface to the Mini Terminal from the electronic mail system is through a serial RS-232 port, which can be direct or through a full duplex modem. The default speed is 1200 bps which results in minimum off-line time for message transfer in or out of the Mini Terminal.

3.1.4 ELECTRONIC MAIL SYSTEM HANDLER

The system handler performs the housekeeping functions such as auto-deletion of various tasks, manages the outgoing queue, places the incoming messages in their respective mail boxes, and performs mail transfer to other electronic mail controllers operating on the same network. All the transactions are time stamped and the status of each message is updated when it is delivered to its destination.

4. THE FEATURES OF THE MAIL SYSTEM

The HF electronic mail network of figure 1 can deliver the messages via the routes shown in figure 2. The two electronic mail controllers A and C can exchange messages via HF and the public switched telephone network; the user of the system has the choice of using either route, depending on availability of the communication channels. A message originated by a user of the A controller can transmit the message to a remote from A, and if this attempt is unsuccessful he can then request from to reroute the message to controller C for transmission. The remotes D and E can not relay received messages automatically to each other. The features of electronic mail system will be described in two sections.

4.1 THE FACILITIES FOR THE REMOTES

The remote stations do not require the use of a controller microcomputer. Messages are created on the Mini Terminal and a routing address is entered in the first line of the text. The message call is then manually initiated. The final destination can be within the local users of the electronic mail microcomputer or another electronic mail computer connected via a Mini Terminal or switched telephone lines. The delivery is then automatic to its final destination. This feature of the system can provide space diversity to networks spread over a wide territory. A remote station can leave a message with the electronic mail system to be delivered to another remote, thereby achieving an effective increase in antenna gain or power at the remote site via base station radio equipment. The remote stations are not capable of interrogating the base station mail boxes.

The remote stations can send messages to the base station for immediate delivery. Upon reception of a message the electronic mail system dials the telephone number of the user's auto-answer modem/printer and delivers the message. This feature is particularly useful for emergency traffic.

4.2 FACILITIES FOR TERRESTRIAL USERS

The user of the system is receiving the benefit of a private mail network, since he can send mail to other users of the system. The system does not require a radio operator to be present to send messages. The electronic mail system will queue the messages until HF propagation conditions allow a radio link to be established. The electronic mail controller can pass a message to a second controller to be put on the transmit queue of the second unit resulting in space diversity, and as a consequence, increased system reliability and throughput.

5. EXAMPLE OF A HF MINI TERMINAL NETWORK INSTALLATION

The Mini Terminal has been extensively tested over a wide range of paths for two years to obtain extensive data on the operations of the terminal in various networks (2). Table 1 lists HF networks which have used the HF Mini Terminal to date. There are several networks in operation with various Canadian government departments serving internal and overseas communication needs. One department has tested the system over a 10000 Km link during which a 300-500 character per minute average throughput was observed and no erroneous characters were printed.

Experimental stations have been installed in Canadian High Arctic to provide an electronic mail system for The Dept. of Health and Welfare. The users of this network are nurses with no radio experience and with a few hours of training. The system serves two villages with populations of 400 and 900 people, 300 Km apart. The HF stations were installed near the nursing stations. The antennas are 27 meter long wideband folded dipoles, constructed with a 9 meter centre pole holding the midpoint of the dipole and the ends of the dipole being secured to poles 1.8 meters above the ground. The system uses 100 Watt pep marine radios driven by the HF Mini Terminal to an output power of 35 Watts. The 3 scan frequencies for the network were selected using a propagation prediction from the Micropredic program (3) to provide an optimal coverage for day /night and seasonal variations.

The results of this experiment will be utilized as a design guide for a larger network of stations serving Arctic communities.

6. CONCLUSION

A HF terminal has been designed and tested that provides reliable operation with minimum operator skills. The users of this message system have been relieved of the burden of channel selection, error correction or preparation of punched tape for teletype equipment. The additional network functions and electronic mail service with a microcomputer system will provide a low cost reliable service to many isolated communities, ships and other remote platforms. The HF network interface to the public switched network will link the remote users to population centres for their everyday communication needs. Several organizations can share a base station and a controller serving a wide range of users.

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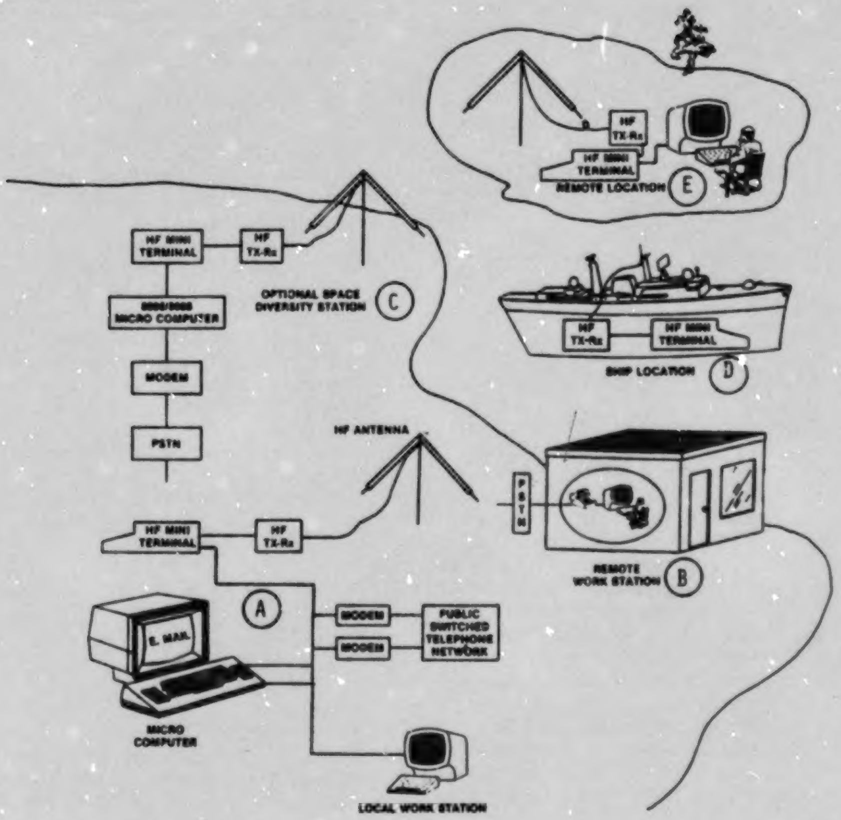
HF TX-Rx
HF MINI TERMINAL
REMOTE LOCATION
E
HF MINI TERMINAL
HF TX-Rx
8088/8088 MICRO COMPUTER
MODEM
PSTN
OPTIONAL SPACE DIVERSITY STATION
C
HF TX-Rx
HF MINI TERMINAL
SHIP LOCATION
D
HF ANTENNA
PSTN
HF MINI TERMINAL
HF TX-Rx
REMOTE WORK STATION
B
A
E. MAIL
MODEM
MODEM
PUBLIC SWITCHED TELEPHONE NETWORK
MICRO COMPUTER
LOCAL WORK STATION

FIGURE 1. ELECTRONIC MAIL [illegible]RK

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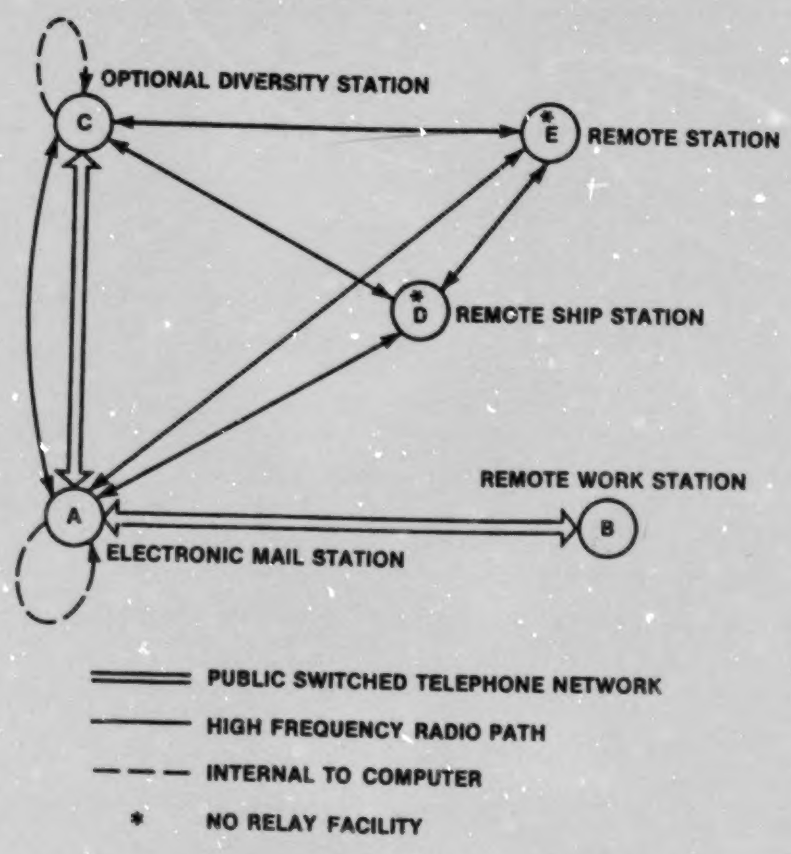
OPTIONAL DIVERSITY STATION
C
*
E
REMOTE STATION
*
D
REMOTE SHIP STATION
REMOTE WORK STATION
A
B
ELECTRONIC MAIL STATION
PUBLIC SWITCHED TELEPHONE NETWORK
HIGH FREQUENCY RADIO PATH
INTERNAL TO COMPUTER
* NO RELAY FACILITY

FIGURE 2. MESSAGE ROUTES FOR ELECTRONIC MAIL NETWORK

FROM	TO	STATUS	DISTANCE Km
OTTAWA	CCG LABRADOR	ICE BREAKER IN DAVIS STRAIT TRIAL JUNE-AUG 1983	2200
OTTAWA	ATHENS BAGHDAD U.K.	TRIAL OCT-NOV 1983	7744 10500 5390
OTTAWA	CENTRAL AMERICA GUATEMALA	OPERATIONAL SINCE NOV-1983	3400
VANCOUVER	SHIPS & LAND STATIONS	DEPT. OF FISHERIES & OCEANS 8 STATION NETWORK. OPERATIONAL SINCE DEC 1983	500
HALIFAX	CYGNUS	DEPT. OF FISHERIES & OCEANS SHIP. TRIAL JAN-APRIL 1984	200
CAMBRIDGE BAY	GJOA HAVEN	DEPT. HEALTH & WELFARE IN ARCTIC CANADA. OPERATIONAL SINCE JUNE 1984	300
VANDERHOOF	INGENIKA	DEPT. OF INDIAN & NORTHERN AFFAIRS. OPERATIONAL SINCE OCT 1984	300
VANCOUVER	PROV. OF BRITISH COLUMBIA	DEPTS. OF FISHERIES & OCEANS, HEALTH & WELFARE, CANADIAN COAST GUARD, COMMUNICATIONS, SHARED NETWORK OPERATIONAL 1985	800

TABLE 1. HF MINI TERMINAL NETWORKS

Impact of Digital Technology on Data Modems

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1. Abstract

In the telecommunications field, the MODEM is one of the devices which adopted digital technology from its early stage of development and has enjoyed the benefit of its most advanced technique.

This paper overviews how the introduction of digital signal processing has contributed to the development of data MODEMs in terms of size, power, capacity and cost by giving some examples, and also discusses the future trend of the MODEM development.

2. Introduction

Since the concept of digital transmission or data transmission was given birth by Sunde(1), Bennet(2) and Lucky(3), the reputed forerunners in the telecommunications field, nearly 25 years have already elapsed and it now appears to be falling into oblivion that this concept was introduced as a new departure from the former concept of analog transmission or voice and speech transmission. At present, all these concepts are being rebuilt into the new, integrated concept of ISDN.

In the process of this technological renovation, magnificient advances have been achieved in the area of data transmission in the conventionally accepted sense of the term, where consistent efforts have been made to realize faster, more accurate and less costly data transmission to meet the rapid changes in social environment brought about by the phenomenal development of computers.(4) - (11) The advances have been notable especially for data MODEMs. Considered in terms of size and cost, it is no exaggeration to say that the development of data MODEMs, assignable largely to the following four features, has been almost unparalleled.

1) Voice frequency band transmission.

2) Digital signal transmission

3) Ease of digital signal processing.

4) Ease of introducing LSIs and VLSIs.

For example, the volume of the 9600 BPS Stand Alone MODEM has been reduced to 1/3 almost every four years since its development. This paper overviews the evolution of data MODEMs in terms of the progress through the four periods of development, i.e., the transistor period, IC period, LSI period and VLSI period, in order to clarify the impact of digital signal processing and LSI technology and look into the future trend of the MODEM development.

3. MODEM Evolution

The evolution of the data MODEM development, which made a start on the strength of voice frequency telegraph technology, was reviewed for each of the following three types of MODEM.

1) The Low Speed Asynchronous MODEM (200/300 BPS)(12) that predominated for 15 years starting from the transistor period.

2) The High Speed Synchronous MODEM (9600 BPS) that predominated for 10 years storting from the IC period after the standard 9600 BPS data transmission system in voice frequency band was established.(13)

3) The High Speed Core Card MODEM (9600/4800/300 BPS) that predominated for 5 years starting from the LSI period after it was adopted as a G3 Facsimile transmission system.(14)

For better understanding of MODEM evolution, its development is shown for each of the above three types in terms of chronological changes in size (Fig. 1), total number of components (Fig. 2), power consumption and weight (Fig. 3), estimated failure rate (fig. 4), and total required manufacturing time (time required for assembling, adjustment and inspection) (Fig. 5). From the past improvements in various MODEM elements shown in these five figures, it is possible to obtain a clear-cut picture of the process of semiconductor development through the four generations of transistor, IC, LSI and VLSI. The above 6 MODEM evaluation factors are summarized in Fig. 6 in terms of rate of reduction the total number of components in Fig. 2 is expressed as a ratio to that of the 2nd (IC) generation 9600 BPS MODEM which embraced the largest number of components of all MODEMs studied in this research. The total required manufacturing time in Fig. 5 is likewise expressed with that of the said 2nd (IC) generation 9600 BPS MODEM taken at 1.00.

All 9600 BPS MODEMs chosen for the present research were of the type which exhibited 4-channel multiplexing functions as well as high-level self-test functions. The G3 Facsimile Core Card MODEM has three modes selectable by external control (V29 9600/7200/4800 BPS, V27 ter 4800/2400 BPS, and V21 300 BPS). Its DTE side has a TTL interface, its line side has no transformer and DC ±12 V and 5 V are supplied from the facsimile equipment.

It can be seen from the said figures that the impact of LSI technology is most conspicuous for the G3 Facsimile High Core MODEM. This is because the Core MODEM has such basic functions as modulation/demodulation and automatic equalization, but none of such functions as control, display, interface, power supply, etc. which are embodied in the Stand Alone MODEMs and difficult to improve in the scale of integration.

It can also be seen that the manufacturing time shows no change from the 3rd to 4th generation, which indicates that factory automation reached the stage of completion when the 3rd generation MODEM was developed.

Changes in weight and power consumption show similar tendencies, which deserves attention as suggesting a necessity resulting from the thermal design of components.

The configuration of the MODEMs reviewed is shown in Figs. 7 and 8, with the LSI and VLSI blocks boxed for clear discrimination from other components.

The changes in MODEM evolution factor shown in Figs. 1 - 5 are presented again in Fig. 9 by the number of each component, newly developed LSI and VLSI, and semiconductor technology applied.

The number of each component shown in Fig. 9 is based on that of the resistor which is used in the largest volume of all components for the 2nd (IC) generation MODEM. Specifically, it is expressed as a ratio to the said resistor number, in much the same way as applied in Fig. 2. Figs. 10.1 - 10.4 show the changes in the number of each component in this way.

As regards the Low Speed MODEM which is based mainly on the analog IC technology, the resistor/capacitor volume did not change very markedly, decreasing to about 1/2 through the four generations. On the other hand, the diode/transistor volume indicates that the improvement of the band pass filter to an SCF (switched capacitor filter) with a one-chip LSI with originate/answer mode changeover function (Fig. 7) for the 4th generation MODEM. The number of ICs, however, increased from the 1st to 3rd generation with the progress of replacement of analog circuits with digital ones.(15)

Regarding the High Speed MODEM, it can be seen that the size reduction, realized by LSI introduction and by incorporating the DSP (digital signal processor) VLSI which makes possible time-sharing use of resources, resulted in approximately an order of reduction in materials requirement.

The improvement of the resistor/capacitor per se cannot be overlooked as an important contributing factor the MODEM development. For example, the 1/8 W carbon film resistor volume was reduced to 1/6 in the ten-year period under review and further to 1/15 by the chip type introduction. The capacitor volume also decreased to about 1/7 for the 1 μF and to about 1/4 for the 10 μF. Such size reduction effects of descrete components have also contributed to the volume change shown in Fig. 1.

4. DSP, LSI Evolution

A comparison between the 3rd and 4th generation MODEMs in the LSI chip space sum and the gates included sum based on Fig. 9 produced the following facts. The number of gates of the G3 Facsimile Core Card MODEM decreased by about 60%, and this percentage indicates the degree of resources saving by digital processing. On the other hand, the silicon chip space per gate decreased to about 1/3.7 owing to the technological progress from 6 μ to 3 μ. Even if the memory unit is included, the silicon chip space decreased to 1/3.

Fig. 11 shows how the silicon chip space per gate decreased as a result of semiconductor technology development, and Fig. 12 shows the total silicon space requirement per MODEM based on Fig. 11.

Looking into the future trend of MODEM development from the anticipated progress of semiconductor technology, it can be foreseen that the Core MODEM will be upgraded to have a one-chip structure with a practical one chip space by the silicon gate length decrease from 2 μ or 1 μ.

It can also be predicted that the High Speed Stand Alone MODEM will be improved to have a 3-chip construction, with the data pump upgraded to a one-chip, the controller to a general-purpose microcomputer, and the interface to a gate array.

The 4th generation MODEM uses four VLSIs, i.e., two customs DSPs developed for signal processing for MODEM (housed in the receiver unit of the MSM 6928-04 and -05), one random gate VLSI (MSM 6929) for receiver control, and one transmitting custom VLSI (MSM 6930) mounting the DSP and the random gate together.

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5. Conclusion

In the foregoing, the writer has discussed the past progress in the LSI technology and its impact on the datam MODEM development, touching also on the necessity of the advance of the High Speed MODEM core to a one-chip unit structure.

It is probable that microcomputers and communication DPSs will be improved incessantly in the future in the scale of integration, processing speed, A/D and D/A conversion function, power consumption, packaging technique, etc., becoming greater in processing capacity and smaller in size to an extent hard to predict at the moment. Data MODEMs will enjoy the benefit of this technological improvement, and it will become possible to integrated the MODEM into various terminal equipment with great ease.

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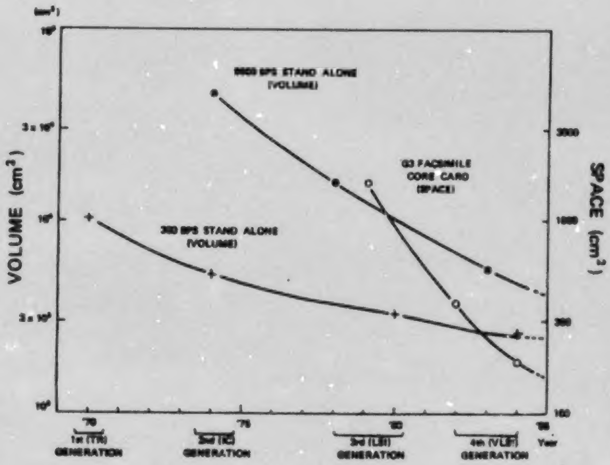
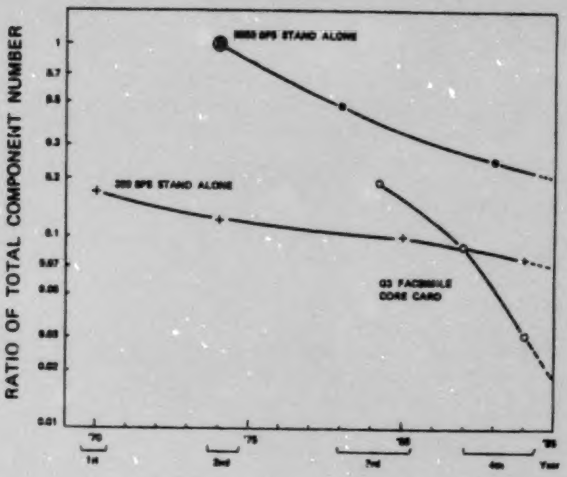


Fig. 1 Changes in MODEM Size



Note: Axis of ordinates indicates the total number of MODEM components expressed by taking that of the 2nd (IC) generation 9600 BPS Stand Alone MODEM at 1.00.

Fig. 2 Changes in Total Number of MODEM Components

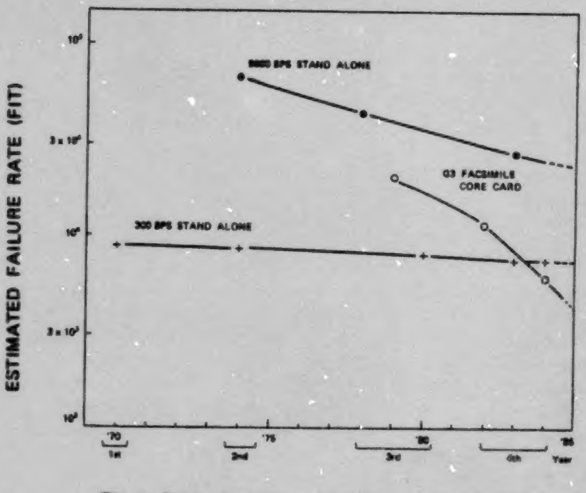
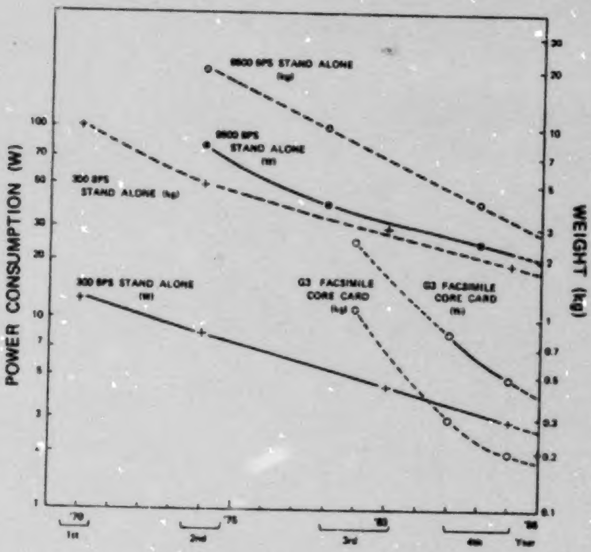


Fig. 4 Changes in Estimated Failure Rate of MODEM



Note: Power consumption is indicated by solid line, weight by dotted line.

Fig. 3 Changes in Power Consumption and Weight of MODEM

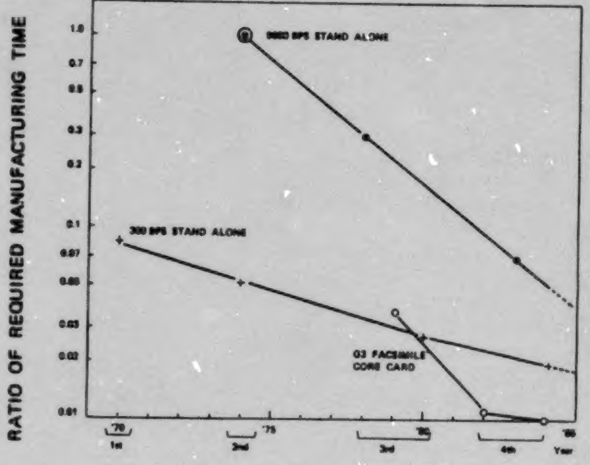


Fig. 5 Changes in MODEM Manufacturing Time (Time required for assembling, adjustment and inspection)

MODEM EVALUATION FACTOR / MODEM TYPE	VOLUME OR SPACE	NUMBER OF COMPONENTS USED	POWER CONSUMPTION	WEIGHT	RELIABILITY	MANUFACTURING TIME
300 BPS STAND ALONE MODEM (14 years)	1/4.1	1/2.1	1/4.8	1/6	1/1.2	1/4.2
9600 BPS STAND ALONE MODEM (9 years)	1/8.3	1/4.0	1/4.0	1/5	1/2.8	1/14.3
G3 FACSIMILE CORE CARD MODEM (6 years)	1/9.6	1/5.1	1/4.9	1/8	1/3.4	1/3.7

Fig. 6 MODEM Evolution Rate

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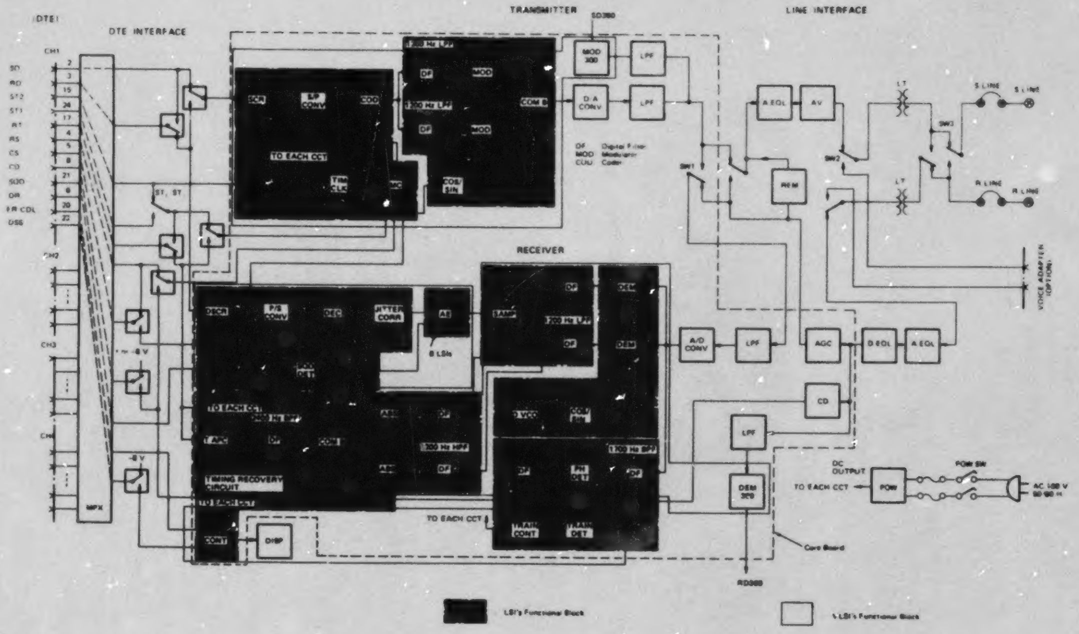
(DTE)
DTE INTERFACE
TRANSMITTER
LINE INTERFACE
SD
RD
ST2
ST1
RT
RS
CS
CD
SQD
DR
F.R CDL
DSS
CH1
CH2
CH3
CH4
2
3
15
24
17
4
5
8
21
6
20
23
MPX
ST, ST
-8 V
SCR
S/P CONV
COD
TO EACH CCT
TIM CLK
1200 Hz LPF
DF
MOD
COM B
COS/ SIN
SD300
MOD 300
LPF
D.A CONV
DF Digital Filter
MOD Modulator
COU Coder
SW1
SW2
SW3
A EQL
AV
REM
LT
S LINE
R LINE
VOICE ADAPTER (OPTION)
RECEIVER
DSCR
P/S CONV
DEC
JITTER CORR
AE
8 LSIs
SAMP
1700 Hz LPF
DEM
LOO DET
TO EACH CCT
2400 Hz BPF
APC
COM
1700 Hz HPF
VCO
1700 Hz BPF
PH DET
TIMING RECOVERY CIRCUIT
TRAIN CONT
TRAIN DET
CONT
DISP
A/D CONV
AGC
D EQL
CD
DEM 300
RD300
Core Board
DC OUTPUT
TO EACH CCT
POW
POW SW
AC 100 V 50/60 Hz
LSI's Functional Block
½ LSI's Functional Block

Fig. 8 9600 BPS Stand Alone Modem and Core Card Modem Block Diagram

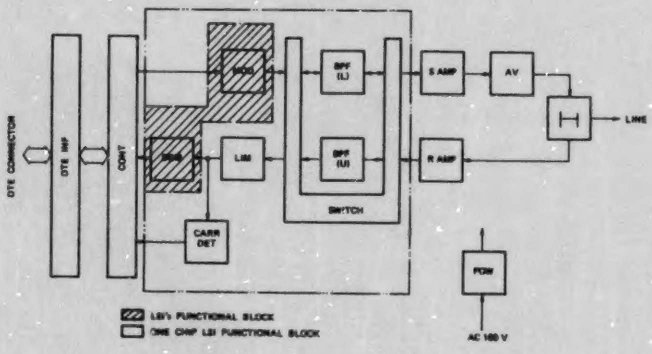
DTE CONNECTOR
DTE INF
CONT
MOD
DEM
LIM
CARR DET
BPF (L)
BPF (U)
SWITCH
S AMP
R AMP
AV
H
LINE
POW
AC 100 V
LSI's FUNCTIONAL BLOCK
ONE CHIP LSI FUNCTIONAL BLOCK

Fig. 7 300 BPS Stand Alone MODEM Block Diagram

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COMPONENT \ TYPE OF MODEMS			300 BPS STAND ALONE	9600 BPS STAND ALONE	G3 FACSIMILE 9600 BPS CORE CARD
1ST GENERATION (TRANSISTOR)		RESISTOR	34.6		
		CAPACITOR	8.03		
		INDUCTOR	1.28		
		DIODE/TRANSISTOR	10.2		
		OTHERS	4.19		
2ND GENERATION (IC)		RESISTOR	16.6	100	
		CAPACITOR	6.29	58.3	
		INDUCTOR	1.16	0	
		DIODE/TRANSISTOR	6.12	73.9	
		IC	1.62	93.13	
		OTHERS	4.77	22.2	
3RD GENERATION (LSI)		RESISTOR	11.1	53.9	21.3
		CAPACITOR	6.4	26	12.3
		DIODE/TRANSISTOR	3.73	10.9	4.77
		IC	4.66	37	9.31
		OTHERS	2.58	11.9	2.1
	HIC	THICK FILM	0	1	0
	LSI	NUMBER	1	16	17
		TECHNOLOGY	E/E NMOS	E/E NMOS	E/E NMOS
		GATE LENGTH (μm)	6	6	6
		CHIP's SUM (mm²)	9	1064.5	1073.5
		SUPPLY VOLT. (V)	+12, +5, −5	+12, +5, −5	+12, +5, −5
		POWER CONS. (mW)	285	20237	20622
		PACKAGING	28P DIP PLASTIC	60P FTP CERAMIC	60P FTP CERAMIC
		GATE INCLUDED	900	38629	38829
4TH GENERATION (VLSI)		RESISTOR	10.9	21.5	3.38
		CAPACITOR	4.54	12.7	1.28
		DIODE/TRANSISTOR	1.28	3.46	0.36
		IC	4.19	18.16	1.75
		OTHERS	2.32	13.4	1.76
	HIC	THICK FILM	0	5	4
	VLSI	NUMBER	1	8	4
		TECHNOLOGY	Si CMOS	Si CMOS	Si CMOS
		GATE LENGTH (μm)	6	6	6
		CHIP's SUM (mm²)	31.86	348	200
		SUPPLY VOLT. (V)	+12, 5	+5	+5
		POWER CONS. (mW)	86	414	390
		PACKAGING	28P DIP PLASTIC	42P DIP PLASTIC	42P DIP PLASTIC
		GATE INCLUDED	1250	27536	21440
		ROM INCLUDED (BIT)	–	89600	89600
		RAM INCLUDED (BIT)	–	5440	5440
		OP AMP INCLUDED	34	–	–
		CAPACITOR SUM	1500 pF	–	–

Note: Component volume is indicated as a ratio to the resistor volume of the 2nd (IC) generation 9600 BPS Stand Alone MODEM taken at 100.

Fig. 9 Changes in MODEM Components

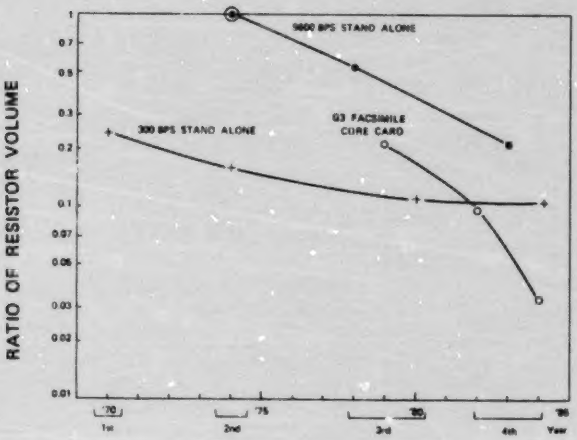

Fig. 10.1 Changes in Resistor Volume

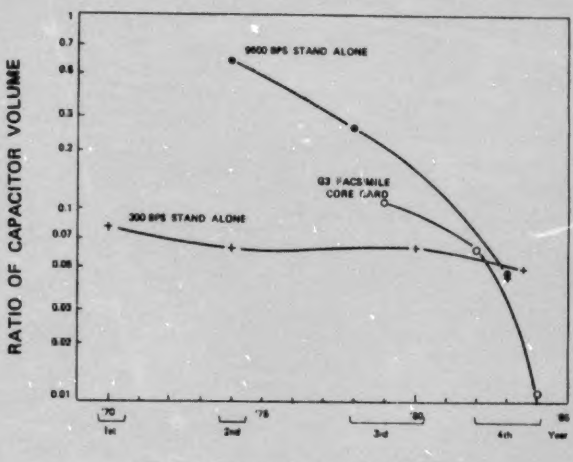

Fig. 10.2 Changes in Capacitor Volume

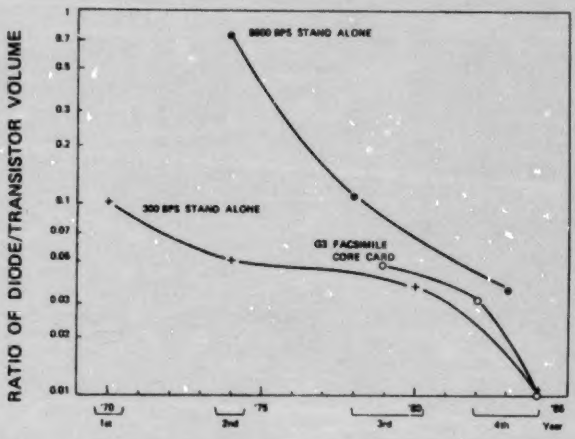

Fig. 10.3 Changes in Diode/Transistor Volume

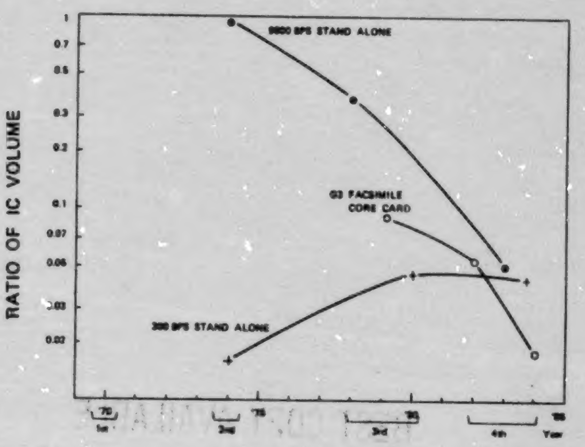

Fig. 10.4 Changes in IC Volume

Fig. 10 Changes in Component Volume Resulting from LSI Introduction

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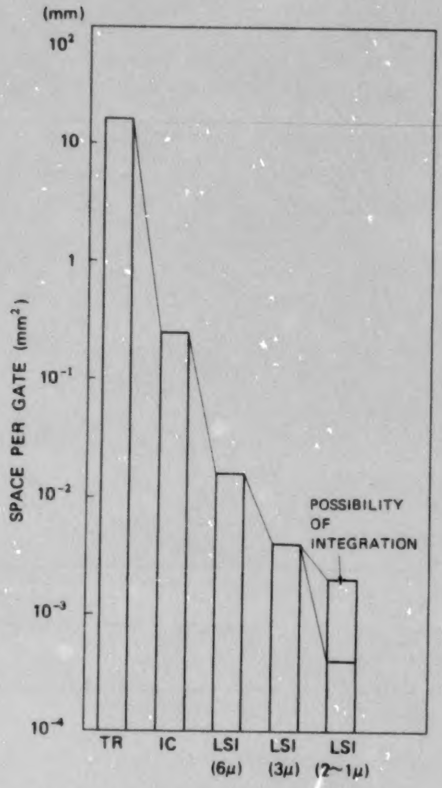

Fig. 11 Changes in Scale of Integration (Changes in Silicon Chip Space per Gate)

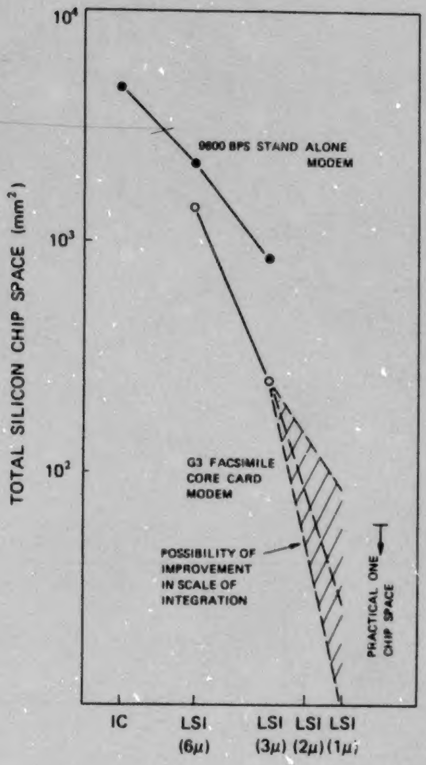

Fig. 12 Silicon Chip Space per MODEM

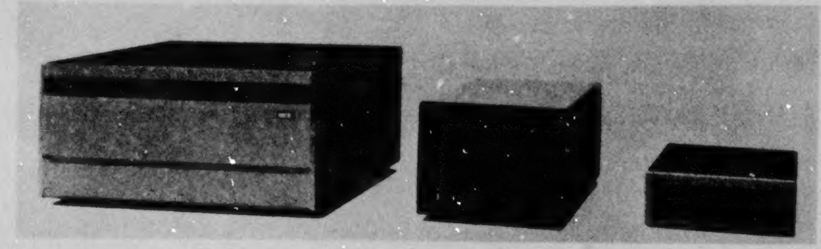

Fig. 13 External View of 9600 BPS Stand Alone MODEM/CCITT Rec V29 (IC, LSI, VLSI)

Notes:
Left: IC generation MODEM
Center: LSI generation MODEM
Right: VLSI generation MODEM

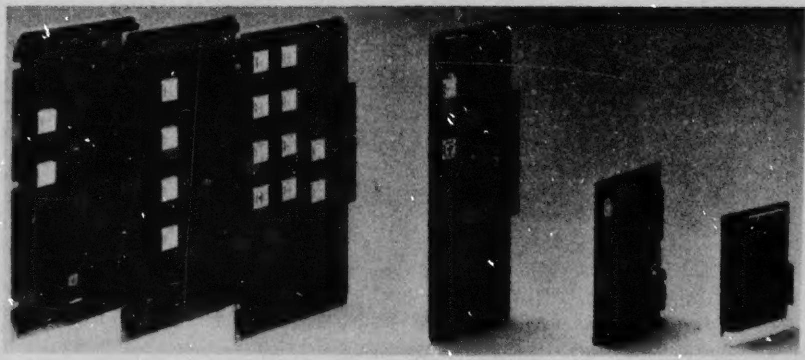

Fig. 14 External View of G3 Facsimile Core MODEM Card (LSI, VLSI, SOP)

Notes:

Left: 3-board LSI generation core card MODEM

Right: All three are VLSI generation one-board Core Card MODEMS in the second place from the right in the above data. Extreme right is a small-type version incorporating SOP (small outline package) component.

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Wednesday, January 16

Managing the Channels and Planning for Transition

INTELSAT AND THE FUTURE OF THE ORBITAL ARC

by

Richard R. Colino
Director General
INTELSAT

ABSTRACT

The World Administrative Radio Conference to establish procedures for the allocation of orbital locations in the geosynchronous orbital arc (GSO), known as WARC-ORB-85, has received a tremendous amount of attention and publicity. This is not surprising, in light of the billions of dollars that has already been invested in geosynchronous communications satellites and the tremendous importance of these satellites to economic, political and social activities at the national, regional and international levels. This paper explains in detail the goals, activities and accomplishments of the INTELSAT Global Satellite System as it has evolved over the last 20 years and, in particular, how it has given definition to the concept of a global common-user system with special emphasis on how INTELSAT has served the Asia/Pacific region.

This paper also emphasizes the importance of the common user systems to achieving the effective utilization of the GSO by all the countries of the world and how, on a practical basis, INTELSAT today and, even more so, in the future, may serve as a primary means by which developing countries can achieve equitable access to communications satellite services. Emphasis is placed on the practical aspects of how communications satellite services will be achieved. Access to an orbital slot is only one factor among a large number of issues that must be addressed to make effective use of the orbital arc. These other issues include such factors as training, system network design, integration of terrestrial and space facilities, financing, and a wide range of technical assistance.

INTELSAT is willing to accept a wide range of planning methods as long as future system requirements can be accommodated. The needs of common-user satellite systems (including INTELSAT, INMARSAT, INTERSPUTNIK, EUTELSAT, and ARABSAT), must be accommodated in order for a new approach to planning of the geosynchronous orbit to be successful. Consensus and mutual understanding of all these points is critical to the success of WARC-ORB-85.

INTRODUCTION

Before we can discuss effective use of the orbital arc and future needs for satellite communications in the Asia/Pacific region, we need to understand first what INTELSAT is already doing for this region today. Many of you already know that INTELSAT now provides two-thirds of the world's international telecommunications services, but what does INTELSAT do for the Asia/Pacific Region?

INTELSAT today provides telecommunication services to some 87 countries and territories in the region as broadly defined. In particular, this means service to 23 in the Pacific Ocean Region and 64 in the Indian Ocean Region. The number of pathways in the Asia/Pacific Region on Pacific and Indian Ocean satellites total over 600, with roughly 400 in the Indian Ocean and 200 in the Pacific. The traffic routes range in size from 1 circuit between American Samoa and Fiji, and over 600 circuits between Japan and the United States.

INTELSAT is not only the world's television network but it is also the video network of the Asia/Pacific region. INTELSAT today provides eight full-time international television leases, of which four serve the Asia/Pacific Region. INTELSAT will also provide about 42,000 half-channel hours of television transmission and reception time this year on an occasional-use basis. More than 6,000 of these hours will be in the Pacific Region. Perhaps more significantly, television in the Pacific Ocean Region is growing more rapidly than anywhere else in the world. The Republic of Korea, for instance, has increased its usage by 1000 percent over the last 5 years (see Figure 1).

Additionally, INTELSAT also provides domestic leases to 26 countries. In the Pacific, domestic leases are already operating in Australia, Malaysia, and Thailand, and domestic leases are in the planning stages in New Zealand, Solomon Islands, People's Republic of China, and the Republic of Korea. The tremendous diversity of INTELSAT's offerings is demonstrated in many ways -- such as by the fact that we provide over 100 different types of telecommunications services (ranging from maritime mobile capacity, which we provide to the INMARSAT Organization); to television broadcast distribution for specialized cable TV networks; to INTELSAT Business Services that utilize a combination of large, medium and small terminals, with the smallest being 3.3 meters in size.

Most recently, we have introduced our INTELNET service. This is a new data distribution service, that can use receive-only microterminals that are remarkably small -- only 75 centimeters (or 2 feet) in diameter. One of our important new service developments, VISTA, had its origins in studies conducted for the South Pacific island countries. VISTA is the low-density telephony service which has been designed to meet the very thin-route requirements for telephony for small countries, such as the island countries of the South Pacific.

INTELSAT serves countries as diverse as Nauru (in the South Pacific, with a population of about 9,000 and an area of 20 square kilometers), and the People's Republic of China (with a population of approximately 1.2 billion people and an area of 9,500,000 square kilometers).

Thus, INTELSAT is the global satellite system for countries with both very big and very small populations; for countries of vast distances and of diminutive size. INTELSAT is the system for very high technology countries, for those with only basic technology, and every level in between. INTELSAT is the satellite system for those countries who have manual and semi-automatic switching systems, on one hand, and for countries who have fully automated electronic digital switching networks on the other. INTELSAT is the system for analog services and for digital services. Finally, it is a system for both prosperous and poor countries. In a very real sense then, INTELSAT is a paradox. It is an organization that many people would think perhaps impossible to invent or to conceive of because of its very diversity and uniqueness of character. We are certainly the world's first, largest, and most geographically and politically diverse common-user satellite system, and we hope we are or will yet become the world's best.

Since INTELSAT began, our space segment, as measured in transponder capacity per year in orbit, reflects almost two orders of magnitude of improvement in 20 years. This has allowed us to reduce charges on twelve different occasions and enabled our charges (when adjusted for inflation) to be some 20 times less than 20 years ago. A part of this improvement in cost effectiveness and performance, of course, comes from the fact that our

INTELSAT VI satellites, which we will launch in 1986/87, possess 170 times greater communications capacity than Early Bird. This means that just one of our satellites in a single geosynchronous orbital slot will derive 170 times greater utilization of that slot than did Early Bird. If we were, indeed, to make similar breakthroughs in the next 20 years, that would be more or less equivalent to expanding the size of the geosynchnous orbital arc by 170 times, as measured in terms of effective utilization of this valuable resource. Such accomplishments are no accident. INTELSAT's character as a non-profit cooperative committed to reducing the cost of service and our commitment to use the orbital arc ever more effectively -- these goals and missions are clearly stated in the INTELSAT Agreement on the basis of negotiated international consensus.

But to return to the issue of globalism and interconnectivity, we find that the basic constraint of the INTELSAT System is indeed in its attempt to connect together small, medium and large countries, utilizing heavy, medium and small streams of traffic. If one analyzes the 1600 different pathways that are currently carried on the INTELSAT System, approximately half of those pathways represent less than 10 percent of revenues, while 10 percent of the pathways represent close to 50 percent of the revenues. These characteristics distinguish INTELSAT from any other satellite system which share few, if any, of these service characteristics or constraints. The only systems which do tend to share certain characteristics with INTELSAT are, in fact, the other common-user satellite systems, such as INMARSAT, EUTELSAT, ARABSAT and INTERSPUTNIK. This is not too surprising, in that several of these systems were constructed using INTELSAT as a model.

PROLIFERATION OF SATELLITES, COMMON-USER SYSTEMS, AND PROSPECTS FOR THE FUTURE

There is today, with the unparalleled success of satellites, however, a growing concern with the problem of proliferation of communications satellite and its implication for a possible saturation of available frequency in a geosynchronous orbital arc. This was, of course, an issue that only the most visionary might have anticipated only 30 years ago.

Arthur C. Clarke, when he wrote his first article for Wireless World in 1945, did not attempt to patent his proposals, in part because he did not envision the invention of the transistor. He pictured the communications satellite as a manned facility whose crew would spend much of their time replacing burned out radio tubes. Even in the early 1950's when a science writer included a chapter in a science text on space flight, rockets, and the exploration of the solar system, it was attacked by critics as "science fiction" and "speculative nonsense" that had no place in a serious scientific work. But with the launch of a series of experimental satellites in the late 1950's, starting with SPUTNIK in 1957, the potential of space applications began to be more broadly recognized.

Even so, in 1965, with the launch of Early Bird and the advent of commercial communications operations from geosynchronous orbit, there was only a total of three satellites in a geosynchronous orbit as of year end 1965. Figure 2 shows the growth over the last 19 years of satellites in operation in the geosynchronous orbit. Today there is a total of 110 satellites in geosynchronous orbit, of which the vast majority are communications satellites. There are, of course, many filings now pending with the IFRB that foretell a further explosive expansion in the number of satellites in the next few years.

One recent study, by Communications 21 Corporation, has projected that the total of all civilian fixed and broadcast communications satellites to be launched from 1985 to the year 2000 will be between 340 and 440 satellites. As a result of satellite proliferation, the FCC, in the U.S., has moved from 5°, to 3°, to 2.5°, to 2° spacing of satellites. Today there is a very large number of communications satellites operating not only in the 6/4 GHz (or C band), but there is a surge of applications for the 14/11 and 14/12 GHz bands (Ku band). Indeed there are several applications for the use of the 20/30 GHz band (or the Ka band).

If the wordwide trends for satellites in geosynchronous orbit were to continue to follow the trend lines established over the last two decades, then there could be problems -- serious problems -- with eventual saturation of the orbital arc. A simple (indeed, a simplistic) straight-line extrapolation of past trends would suggest that we would have 4,000 satellites in orbit by the year 2005, and well over 100,000 by the year 2025 or, in effect, a satellite at less than three-kilometer intervals in the geosynchronous orbital arc. This could, indeed, give rise to serious spacing problems, if not in terms of physical spacing, certainly in terms of electromagnetic radiation. But fortunately, such extrapolations overstate the extent of the problem. Indeed, with judicious use of the many bands available, from VHF and UHF frequencies up to SHF and optical frequencies, the 600 or so satellites projected for launch into geosynchronous orbit by the end of the 20th century do seem likely to be accommodated.

There is, however, a great danger in predicting the future by simply looking into the future through the rear-view mirror of history. First of all, we can anticipate the development of new technologies, such as multi-beam antenna, electronic "hopping" or "scanning" beams, on-board processing, inter-satellite links, satellite clusters or even, in the much longer future, space platforms. These technologies offer the promise that a single-point geosynchonous orbit can be utilized perhaps 100 times more efficiently than today's satellites. Despite the promise of tomorrow's technologies, we must deal with today's problems. We, at INTELSAT, feel we have a very special obligation to make the most effective and cost-efficient use of the geosynchronous orbital arc as possible. This is because we feel, in many ways, that as the largest and most integrated system on a global basis, we should set high standards that can be used as an example by all of our members and users, in terms of their national and regional programs.

Perhaps the greatest efficiency that has already been achieved in the use of the geosynchronous orbital arc is with respect to common-user systems. INTELSAT, with what is essentially a 15-satellite network, today provides international overseas communications services to 170 different countries and territories; domestic services to 26 countries; and combined domestic and international video networks to 8 countries. The 300 international earth stations in the INTELSAT System today represent some 1,600 international earth station-to-earth station pathways, and this does not include the many terresterial extensions that branch out from these earth stations as well.

With the advent of the INTELSAT Business Service and the INTELNET data network and distribution service, that allows the use of very small and low-cost microterminals, it is, indeed, possible that the number of international INTELSAT earth stations could, in the next decade, increase by more than an order of magnitude. The number of countries leasing domestic capacity from INTELSAT is expected to grow by more than 20 by the early 1990's. The fact that all of these service applications, including capacity for sparing and restoral of service, can be achieved essentially by 15 satellites, is, in many ways, itself a remarkable achievement, in terms of not only cost-efficient operation, but in terms of its practical and effective implementation of a type of international cooperation that works to conserve the geosynchronous orbital arc.

In preparation for the World Administrative Radio Conference on Orbital Locations (1985 and 1988), INTELSAT has looked at possible future demands for domestic services, particularly for third-world countries. In one of these studies, it was concluded that there are approximately 100 countries where it is unlikely that within the next two decades there would be sufficient service needs to justify the launching of a dedicated satellite system. In this study, the projected satellite communications requirements, using several traffic techniques, were estimated to be equivalent to just over 200 transponders (of 36 MHz bandwidth) for these 100 countries. The INTELSAT System, if properly planned and engineered, we believe, could go a very long way to guaranteeing service access to the geosynchronous orbit (GSO). In a practical sense, it is probably as important, if not more important, to have guaranteed access to "service" in the GSO as it is to have a "guarantee" of an orbital slot that may cost hundreds of millions of dollars to effectively utilize. There are, of course, other common-user systems established under international agreements (such as INMARSAT, INTERSPUTNIK, EUTELSAT and ARABSAT), that may be able to "guarantee" a portion of those needs for access to satellites to meet low-density service requirements.

Nevertheless, INTELSAT, in terms of lease costs, orbital locations and other operational services factors, is likely to be the system most extensively utilized to fulfill the role of being the basic "guarantor" of service access to developing countries. This is perhaps not surprising when it is recalled that over three-fourths of INTELSAT's member countries and users fall into this category.

Thus, at the risk of being both somewhat repetitive and very precise, I wish to emphasize that when I extol the virtues of common-user systems in conserving the orbital arc and guaranteeing service access, I am not suggesting that INTELSAT is the exclusive mechanism for consolidation of national, regional and international traffic requirements or the sole "guarantor" of geosynchronous orbital arc access for developing country service requirements. I am saying, however, that INTELSAT is perhaps the world's best hope for achieving and maintaining cost-effective, reliable, and globally interconnected satellite service, which also allows the best optimization of the use of the geosynchronous orbital arc.

Recently, there have been initiatives that are attempting to establish private satellite networks based on heavy routes of traffic. These are attempts to maximize corporate profits and are targeted only for heavy-density streams. These ventures certainly do not have as their objective conservation of the orbital arc or consolidation and pooling of resources to benefit all countries of the world -- be they developed, industrializing or developing countries.

INTELSAT AND WARC-ORB-85

INTELSAT, with its 109 member countries has, as you might imagine, at times had some difficulty in trying to accommodate the conflicting views among its diverse membership on goals and objectives for the WARC-ORB-85 Conference. The key issue, of course, has been "whether to" and "how to" plan the use of the orbital arc. Answers to these difficult questions must be found within the next eight months. Regardless of the answer found concerning the planning of the geosynchronous orbital arc (and increased planning seems inevitable), we sincerely hope that the process clearly recognizes and protects the orbital location necessary for INTELSAT to maintain its established international, regional and domestic services. This, we hope, is an objective that all of our members and users both understand and support, because INTELSAT's requirements are, quite literally, the world's requirements.

At the Conference Preparatory Meeting (CPM) for WARC-ORB-85, seven different concepts for the planning of the geosynchronous orbital arc were identified and analyzed. These seven methods represent a broad range of philosophies and approaches to this subject. Some of the methods are more flexible than others. Some are longer term, while others are shorter term. Some concepts place great stress on the practicality of use, as well as the stimulation of technological innovation. Finally, other methods place much greater stress on guaranteeing access to the geosynchronous orbit for all countries and a sense of equity in the planning process. Some of the approaches are quite straightforward and simple, while others are much more complex and involve the extensive use of computers for their successful implementation.

INTELSAT has analyzed each of these seven planning methods and concluded that all of them could accommodate INTELSAT's longer term operational needs [emphasis added]. The key element in adopting new planning methods is adequate protection of INTELSAT's future system requirements. For the Conference to be successful, a very practical and non-theoretical approach must be taken by all concerned. All the countries represented should seek to make sure that the real objective is achieved -- namely, guaranteeing service to all countries of the world. Service access could mean assignment of orbital locations to particular countries, or it could mean access to INTELSAT and other common-user systems that can accommodate their needs. Perhaps most likely, it may mean a practical combination of such methods.

Indeed, it is important to recognize that access to the geosynchronous orbital arc is usually only the beginning of the process of expanding telecommunications service capabilities. For instance, INTELSAT Signatories look to the global satellite system for much more than just satellite capacity. They also look to INTELSAT for assistance with training programs, feasibility and viability studies for the design of new systems, technical engineering, and assistance with the implementation and initial testing of earth stations.

All of this is done through the INTELSAT Assistance and Development Program (IADP). Perhaps in the future, if INTELSAT implements the concept of an INTELSAT Development Fund (IDF), we may serve as a catalyst to help arrange capital financing for both the terrestrial and space segment portions of new satellite systems in developing countries. All of these services (whether training, system design, financing, etc.), are required to make the benefits of the geosynchronous orbital arc available to all countries -- particularly developing countries. In short, the practical use of satellite communications by developing countries involves much more than obtaining an "orbital slot." All countries, but particularly developing countries, thus should take very broad perspective of exactly how they in fact can and will make use of the geosyschronous orbit. All countries must plan for the total range of service and assistance that may be required to translate the use of a communiations satellite into a practical reality.

In devising planning methods that not only are equitable and reasonable, but also practical and easily implementable, one must look at why countries feel planning is necessary. In particular, it would seem that the importance that is placed by many countries on the question of "guaranteed access" has been precipitated by the current very rapid utilization of this resource by only a few countries. This, in turn, gives rise to feelings of concern that "protections" and "guarantees" are required.

Developing countries, in particular, look at the current patterns of "consumption" of the geosynchronous orbit with some concern. They might well equate their views of why "planning" is necessary to a doctor advising a village that they all should follow a proper and nutritional diet and that overeating is unhealthy. They would argue that it is to everyone's benefit to watch what they eat, to make sure that everyone follow a balanced diet, and that no one is consuming more calories than are required. In this way, the food is shared in a reasonable way. Thus, some do not go hungry and others do not end up being obese. Certainly, it is much easier for a few to go on a diet, rather than having a banquet for only a very few people, while late-comers must go hungry.

Now, clearly, it is not wise to push this analogy too far. Fortunately, there is still room for everyone at the GSO table, but concerns about tomorrow have been growing. Feelings of inequity always run very high when hunger and overconsumption co-exist.

I hope my analogy thus gives us all food for thought. At WARC-ORB-85, the assembled countries should be able to devise the right combination of ingredients to achieve a global balance in our eating habits. That combination might well be a "stew" that blends together common-user systems, technological innovation, and reasonable timetables for updating and improving the world's GSO diet as nutritional breakthroughs are made. There have already been numerous proposals made that would suggest that a balanced diet for all can be reasonably achieved. Proposals include such ideas as reverse-band operation (in the C-Band) in Third World countries, as well as proposals for band segmentation or other concepts that could be integrated into current operational procedures for the geosynchronous orbit. Such proposals suggest that reasonable techniques could be found to share the fruits of the geosynchronous orbital arc.

CONCLUSIONS

New orbital use techniques, together with the common-user satellite system approach to the orbital arc, can help guarantee that reasonable, practical and perhaps even far-sighted approaches can be found. We all have a common interest in ensuring that the benefits of the geosynchronous orbital arc are available and equitably shared by all countries of our planet. The key is the recognition that practical solutions involve far more than such a country's name on a piece of celestial real estate. Practical and comprehensive solutions must also involve training of personnel, financing, effective integration of space and terrestrial communications, and many other features addressed in the recently concluded Maitland Commission report. Here INTELSAT, the ITU, development banks and other common users will necessarily play an important role in the future.

With good will, pragmatic problem solving, and perhaps a little luck, we ultimately should be able to devise a globally balanced and healthy diet for all countries that allows us to share our very important global resource, the geosynchronous orbital arc, in a just, equitable, cost-effective, and perhaps even clever way. The solution will be found, because it must be. When the problems of WARC/ORB '85 are behind us, then INTELSAT will be able to return again to other challenges and issues that face it. Rest assured that those challenges include ensuring that INTELSAT does remain a flexible, cost-effective, innovative and responsible satellite system that will meet effectively the Asia/Pacific international regional and domestic communities' needs.

FIGURE 1

GROWTH IN
INTELSAT TELEVISION SERVICE
FOR SOME ABU MEMBER COUNTRIES

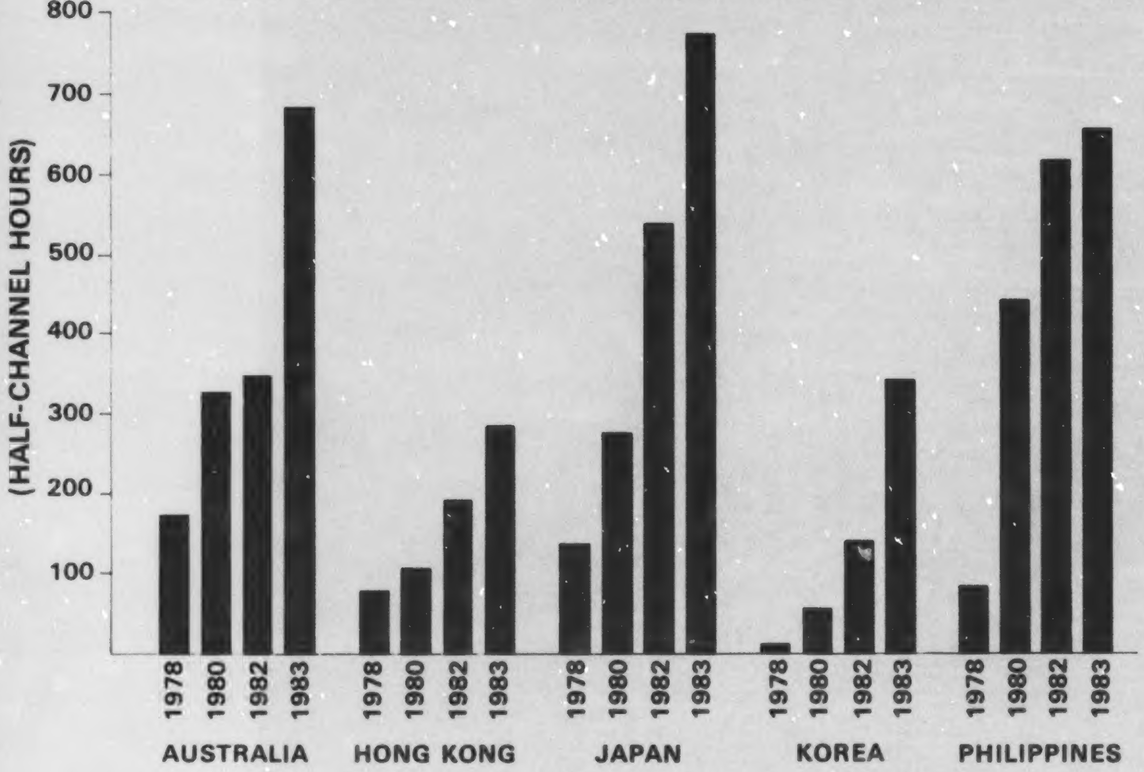
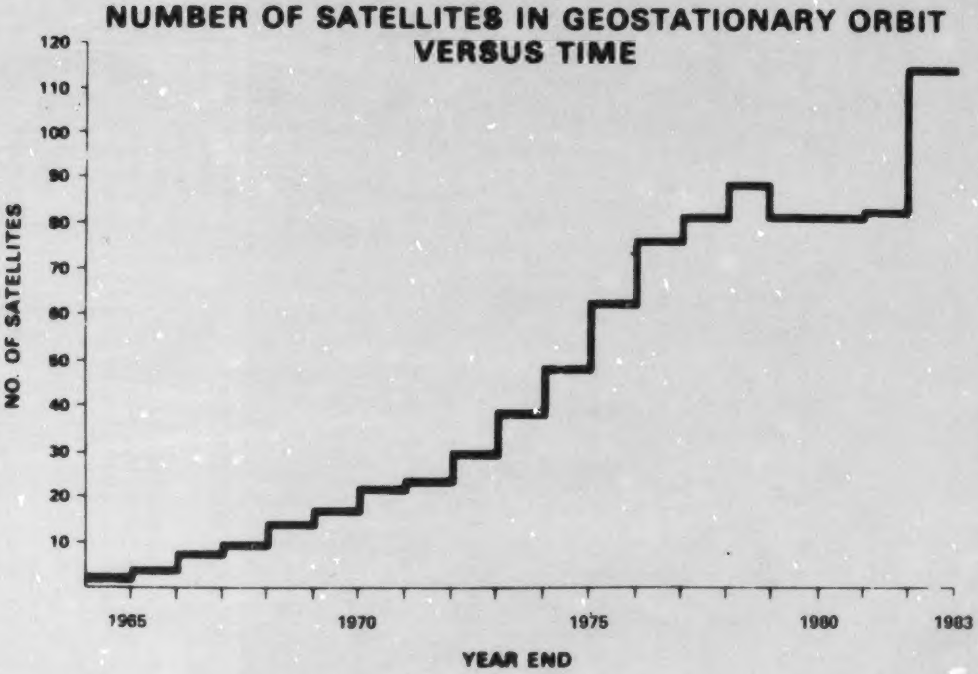


FIGURE 2



NUMBER OF SATELLITES IN GEOSTATIONARY ORBIT VERSUS TIME

International Regulations concerning
Space Radiocommunication Services

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ABSTRACT

This paper describes the development of international regulations over the past twenty years, the essential purpose of the existing regulations and describes the activities foreseen in the forthcoming ITU world conferences on orbit planning in 1985 and 1988.

1. INTRODUCTION

Within the general theme of Telecommunications for Pacific Development and the specific theme of the present meeting, viz. development and introduction of digital technology, the knowledge and application of the international regulations concerning space radiocommunication services is indispensable. The digital technology is not commonly used at present in international space radiocommunication services but it is at the doorstep of space radiocommunication technology, and the merger of the two will certainly improve the capacity, quality and reliability of telecommunication services that will be available to the general public in the near future. The purpose of this paper is to explain in a simple and brief manner the development of international regulations over the past twenty years, the essential purpose and outline of the existing regulations and describe the activities foreseen in the forthcoming ITU world conferences in 1985 and 1988 on planning of the geostationary satellite orbit.

2. DEVELOPMENT OF THE REGULATORY PROVISIONS IN FORCE

2.1 Statutory provisions governing the activities of the ITU

The International Telecommunication Union (ITU), by virtue of its Agreement with the United Nations, is recognized as the specialized agency of the United Nations responsible for taking such action as may be appropriate under its basic instrument for the accomplishment of the purposes set forth in its basic instrument, which is the International Telecommunication Convention. One of the actions to be taken by the Union for the accomplishment of its purposes is "to effect allocation of the radio frequency spectrum and registration of radio frequency assignments in order to avoid harmful interference between radio stations of different countries" (No. 18 of the Convention), "coordinate efforts with a view to harmonizing the development of telecommunication facilities, notably those using space techniques, with a view to full advantage being taken of their possibilities" (No. 21 of the Convention), and "to undertake studies, make regulations, adopt resolutions, formulate recommendations and opinions and collect and publish information concerning telecommunication matters (No. 24 of the Convention).

2.2 Nature of ITU activities

The technical studies are undertaken and the resulting recommendations and opinions are formulated in the field of radiocommunication by a permanent organ of the Union called the International Radio Consultative Committee (CCIR) in which normally all countries as well as industrial, scientific and operating agencies recognized by them participate. The international regulations for harmonizing the development of telecommunication facilities, notably those using space techniques, are adopted at world administrative radio conferences in which normally all the countries, Members of the ITU, participate. The Final Acts of these conferences are aimed at revising the Radio Regulations which are annexed to the Convention and thus have a force of international law. Uniform application of the Radio Regulations by all countries, Members of the ITU, is ensured by the International Frequency Registration Board (IFRB), which is another permanent organ of the ITU, with a view to operation of the maximum praticable number of radio channels in the radio frequency spectrum, and with a view to equitable, effective and economic use of the geostationary-satellite orbit.

2.3 Activities before and during 1959

The ITU began space radiocommunication studies through the CCIR in 1958, after the first satellite was launched. The Ordinary Administrative Radio Conference, (OARC), Geneva, 1959, in carrying out a general revision of the Radio Regulations, made the first frequency allocations to space services for space research.

2.4 EARC, 1963

An Extraordinary Administrative Radio Conference was convened in 1963, with a view to allocating new frequency bands for space radiocommunication purposes and incorporating in the Radio Regulations procedures for their orbital utilization. This Conference set the trend of providing a regulatory framework uniformly applicable throughout the world for equitable and rational use of the frequency bands allocated to space radiocommunication services and developing regulations for that purpose before the operational systems came into being. The notable features of the EARC, 1963, were:

a) the allocation of new frequency bands to various space radiocommunication services;

b) adoption of a procedure for coordinating frequency assignments to earth stations with terrestrial stations; and

c) a special procedure for assignment and use of frequencies assigned to stations of space services and their notification to the IFRB individually for transmission and for reception, both by the space stations and by the earth stations communicating with them.

2.5 WARC-ST, 1971

ITU held its second World Administrative Radio Conference for Space Telecommunications in Geneva in 1971. From the beginning of space radiocommunications it had been obvious that space radiocommunication services could not be allocated exclusive frequency bends and had to share these bands with terrestrial services. Furthermore, in 1971 the advances in technology made it possible to envisage extensive utilization of the geostationary-satellite orbit by space radiocommunication services. The Conference took these facts into account and, based on the technical studies made by the CCIR, took the following major decisions:

a) it revised the Table of Frequency Allocations and moved the upper limit of the Table from 40 GHz to 275 GHz, in which the total spectrum allocated to space radiocommunication services, while still remaining on a shared basis with terrestrial radiommunication services, was increased;

b) for the first time, frequency bands were allocated to the broadcasting-satellite service under certain specific conditions which were different from those imposed on the other space radiocommunication services, for obvious reasons;

c) the procedure adopted in a skeletal form in the 1963 Conference, to give advance information about the planned satellite networks (set out in Resolution 1A of EARC, 1963), was revised and incorporated in the Radio Regulations as the first stage of a new compulsory coordination procedure between stations belonging to different geostationary-satellite networks;

d) the procedure for coordination between the earth and terrestrial stations was revised and updated;

e) sharing criteria between different space radiocommunication services on the one hand and space services and terrestrial services on the other hand were more precisely defined, and, finally

f) provisions were incorporated in the Radio Regulations to enable Adminisrations to request for assistance from the IFRB in applying the different regulatory procedures which were complex.

2.6 WARC-BC SAT, 1977

The World Broadcasting-Satellite Administrative Radio Conference, Geneva, 1977, established sharing criteria for frequency bands around 12 GHz between the broadcasting-satellite service and other services to which these bands are allocated, and adopted a Plan for the broadcasting-satellite service in the bands 11.7-12.2 GHz in Region 3 (Asia and Oceania) and 11.7-12.5 GHz in Region 1 (Europe, including Asian part of USSR, Middle East and Africa), together with procedures for modifying the Plan. It adopted a series of procedures similar to those in the Radio Regulations applicable to other space radiocommunication services for the coordination, notification and recording of frequency assignments to stations of all services in the bands concerned.

2.7 WARC-1979

2.7.1 This World Administrative Radio Conference, convened to revise the whole of the Radio Regulations, met twenty years after the last conference of the same type, namely the OARC, 1959. It met in Geneva for eleven weeks and adopted the revised Radio Regulations, Geneva, 1979, which entered into force on 1 January 1982.

2.7.2 The Conference revised several provisions relating to space radiocommunications, in particular those relating to the allocation of frequencies to services as well as the technical criteria for sharing the same frequency bands, procedures for the advance publication of information on satellite networks, coordination and notification of frequency assignments to stations in space services and incorporation in the Radio Regulations of the Final Acts of the WARC-BC-SAT, 1977.

2.7.3 The principle of the equitable use by all countries, with equal rights, of the geostationary-satellite orbit and of the frequency bands allocated to space radiocommunication services, was maintained (Resolution No. 2). In order to avoid conferring any rights to a particular Administation of a position on the geostationary-satellite orbit, and to secure rational and efficient use of the radio frequency spectrum and the orbit, the notion of a period of validity of frequency assignments to space stations was introduced on an experimental basis (Resolution No. 4).

2.7.4 The Conference decided to convene a World Administrative Radio Conference to be held in two Sessions, to guarantee, in practice, for all countries equitable access to the geostationary-satellite orbit and the frequency bands allocated to space services utilizing it to the extent possible (Resolution No. 3).

2.7.5 In the meantime, the Conference decided that the feeder links to space stations in the broadcasting-satellite service operating in the 12 GHz band under the Plan drawn up in WARC-BC SAT, 1977, should be operated in accordance with the Plans to be drawn up in the bands allocated for this purpose. Pending the establishment of such Plans, it adopted a provisional procedure (Resolution No. 101).

2.8 RARC, 1983

2.8.1 The Regional Administrative Radio Conference for the Planning of the Broadcasting-Satellite Service in Region 2 (the Americas, Caribbean and the part of the Pacific Ocean not included in Region 3) was convened in Geneva in 1983. This Conference adopted a Plan for the broadcasting-satellite service in Region 2 in the band 12.2 - 12.7 GHz and adopted associated procedures for modification of these Plans.

2.8.2 These provisions and associated Plans for the broadcasting-satellite service and the feeder links will come into force at a date to be decided by the World Administrative Radio Conference for the Planning of the Geostationary-Satellite Orbit (WARC-ORB(1))to be held in Geneva in August-September 1985.

2.9 Plenipotentiary Conference, Nairobi, 1982

The Plenipotentiary Conference of the ITU, which is the supreme organ of the ITU, revised the International Telecommunication Convention, when it met in Nairobi in 1982. Some of the basic principles which had developed in the evolution of the Radio Regulations in the various Conferences mentioned earlier were incorporated as essential tasks of the International Frequency Registration Board (Nos. 78 and 79 of the Convention, in particular).

3. INTERFERENCE MECHANISMS GOVERNING THE PROVISIONS OF THE RADIO REGULATIONS

In order to understand clearly the various provisions which have been adopted and refined since the first Space Conference, it should be borne in mind that, in the majority of cases, space radiocommunication services share the same frequency bands with terrestrial services on the basis of equal rights for the utilization of the spectrum. Furthermore, in a given space radiocommunication service, there could be more than one satellite system which use the same frequency bands for the uplinks and the same, though some other frequency bands, for the downlinks. These two systems could belong to two different Administrations and could ocupy positions on the geostationary-satellite orbit such that they may be mutual sources of interference. Taking these considerations into account, Figure 1 illustrates the various modes of interference that can occur.

3.1 An examination of the situation in any frequency band shared with equal rights by space and terrestrial radiocommunication services will show that the following types of stations may be found to operate simultaneously on the same frequency or adjacent frequencies:

- terrestrial stations (transmitting and receiving);
- earth stations (transmitting and receiving);
- space stations (transmitting and receiving).

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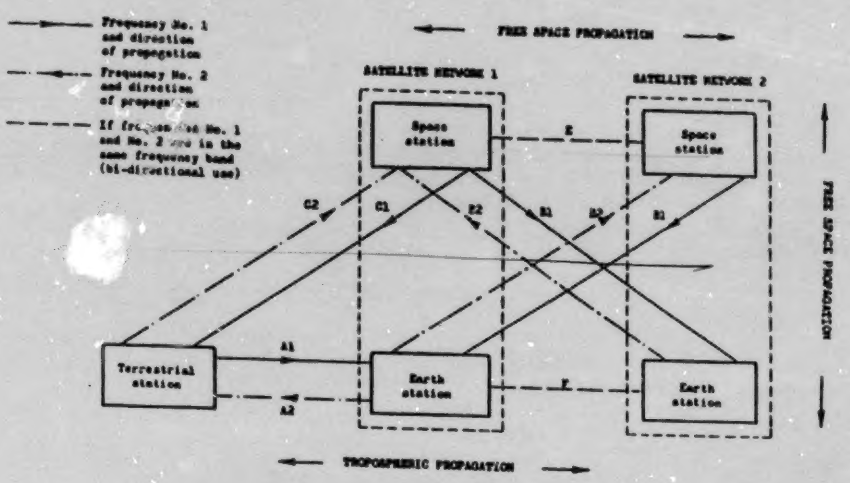

Frequency No. 1 and direction of propagation
Frequency No. 2 and direction of propagation
If frequencies No. 1 and No. 2 are in the same frequency band (bi-directional use)
FREE SPACE PROPAGATION
SATELLITE NETWORK 1
SATELLITE NETWORK 2
Space station
Space station
E
C2
C1
B2
B1
B2
B1
FREE SPACE PROPAGATION
Terrestrial station
A1
Earth station
F
Earth station
A2
TROPOSPHERIC PROPAGATION

FIGURE 1

Modes of interference concerning a space service in the frequency bands allocated with equal rights with the terrestrial radiocommunication

3.2 The modes of interference which may occur between any two of these stations in a given frequency band and which may need consideration depend on the type of allocation for the space service which may be either:

- restricted for the Earth-to-space direction only, or
- restricted for the space-to-Earth direction only, or
- for bi-directional use in the same frequency band.

3.3 Consequently, the possible modes of interference in all cases of interference between space and terrestrial radiocommunication stations are (Figure 1):

A1 Terrestrial station transmissions possibly causing interference to reception by an earth station.

A2 Earth station transissions possibly causing interference to reception by a terrestrial station.

C1 Space station transmission possibly causing interference to reception by a terrestrial station.

C2 Terrestrial station transmission possibly causing interference to reception by a space station.

3.4 Modes of interference between stations of different space systems in frequency bands with separated Earth-to-space and space-to-Earth allocations:

B1 Space station transmission of one space system possibly causing interference to reception by an earth station of another space system.

B2 Earth station transmission of one space system possibly causing interference to reception by a space station of another space system.

3.5 Modes of interference between stations of different space systems in frequency bands for bi-directional use extend the above modes B1 and B2 by:

E Space station transmission of one space system possibly causing interference to reception by a space station of another space system.

F Earth station transmission of one space system possibly causing interference to reception by an earth station of another space system.

3.6 Modes A2, C1 and C2 are regulated by imposing suitable limitations on the radiated energy, in specific directions. Modes A1 and A2 related to interference paths between earth stations and terrestrial stations are dealt with by a procedure of compulsory coordination, which has to be effected between Administrations, in case when the "coordination area" around an earth station (either transmitting or receiving) includes the territory of another country. Modes B1, B2, E and F related to interference paths between one space system and another space system are dealt with by another procedure of compulsory coordination which has to be effected between Administrations in case when the estimated interference from one system into the other exceeds an agreed percentage of the inherent internal system noise.

4. PROVISIONS OF THE RADIO REGULATIONS

4.1 General

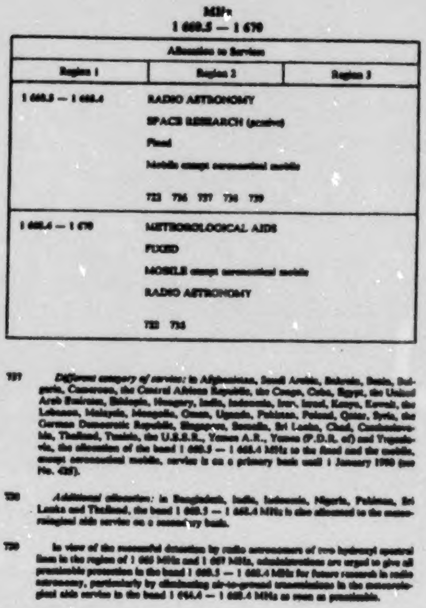
The Radio Regulations presently in force are those adopted by the WARC-79. In so far as space services are concerned, some provisions applicable to the frequency bands between 11.7 and 12.7 GHz have been modified by the Regional Conference for the Broadcasting-Satellite Service held in 1983. However, these modifications will not enter into force until the WARC-ORB(1), 1985, takes a decision on the incorporation of these modifications in the Radio Regulations and the date of their enry into force.

4.2 Article 1 - Definitions

Article 1 of the Radio Regulations contains definitions of terms related to space services, as applied in other provisions of the Radio Regulations. Among these terms are definitions of 16 space services. There is a separate section (Section VIII) in this Article which defines technical terms relating to space.

4.3 Article 8 - Table of Frequency Allocations

This Article contains the Table of Frequency Allocations including the associated footnotes which are part of the Table. For the purposes of frequency allocations, the world is divided into three Regions. Region 1 essentially consists of Europe (including the whole of USSR and Mongolia) Africa and the Middle East. Region 2 consists of the Americas, Caribbean area, Greenland and part of the Pacific Ocean not included in Region 3. Region 3 consists of South-East Asia, Australasia and South Pacific. The allocations are of three categories, namely, primary, permitted and secondary. The Table consists of two parts, one is the main frame of the Table and the other is the associated footnotes. The main frame of the Table indicates the allocations together with their category. The footnotes contain either the conditions of utilization for certain services indicated in the main frame of the Table, or additional or alternative allocations of certain frequency bands to specific services in countries or areas smaller than a Region, which are different from those indicated in the main frame. In some cases a footnote may indicate that the category of allocation in the main frame does not apply to specific countries where the category is different. Such cases of different category of service are also included in the footnotes. An illustrative example of a sample page of the Table of Frequency Allocations is reproduced as Figure 2.



MHz
1 660.5 — 1 670

Allocation to Services		
Region 1	Region 2	Region 3
1 660.5 — 1 668.4	RADIO ASTRONOMY SPACE RESEARCH (passive) Fixed Mobile except aeronautical mobile 722 736 737 738 739	
1 668.4 — 1 670	METEOROLOGICAL AIDS FIXED MOBILE except aeronautical mobile RADIO ASTRONOMY 722 736	

Figure 2

The allocations to space services are spread throughout the spectrum from 2500 kHz up to 381 GHz (the Table covers9 kHz to 400 GHz). As mentioned earlier, there are no allocations to space services which are not shared by either other space services or by terrestrial services, or both. The allocations to space services are, where necessary, restricted to a specific direction, such as space-to-Earth, Earth-to-space or space-to-space, depending upon the nature of application and the other servics with which the frequency band is shared. If such a restriction is not indicated, the band can be used by the space service concerned without restriction on the directiôn of transmission. There are certain frequency bands allocated to "passive" space services, particularly for exploration of the Earth, its environment (in particular, meteorology) and resources. Some other frequency bands are allocated for radio astronomy, which is also a passive service, and three frequency bands are allocated for "search for intentional emission of extra-terrestrial origin".

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4.4 Article 10 - International Frequency Registration Board

This Article describes the functions of the International Frequency Registration Board and its methods of work. The functions of the Board include the processing of frequency assignment notices, including information about any associated orbital locations of geostationary satellites received from Administrations, for recording in the Master International Frequency Register (RR 992), and the processing of information received from Administrations in application of the advance publication, coordination and other procedures of the Radio Regulations and the Final Acts of administrative radio conferences, and the provision of assistance to Administrations of these matters, at their request; (RR 993). The functions also include the provision of assistance by the IFRB to Administrations in need of special assistance to improve the use of the radio frequency spectrum and the provision of technical assistance in preparation for, and organization of, radio conferences (RR 999 and RR 1003). These and other functions of the Board are carried out by the Board with the assistance of its specialized secretariat, consisting presently of about 140 persons. The Board holds its formal meetings at least once a week, at which it decides on the recording, or otherwise, of the frequency assignment notices received and examined by it in accordance with the provisions of the Radio Regulations. The records of these formal meetings of the Board are maintained in the working languages of the ITU, and are available for public inspection at the offices of the Board.

4.5 Articles 11, 12 and 13 - Procedures of coordination, notification and recording of frequency assignments to stations of the space services and to stations of the terrestrial services which share the same frequency bands

4.5.1 General

The procedures of these Articles are designed to ensure that any frequency assignment to be used for transmission or reception by a station in a space service or in a terrestrial service sharing the same frequency bands, shall be notified to the Board:

a) if the use of the frequency concerned is capable of causing harmful interference to any service of another Administration; or

b) if the frequency is to be used for international radiocommunications; or

c) if it is desired to obtain international recognition of the use of a frequency.

The notification is to be sent to the IFRB using a prescribed form, which contains the minimum essential information to enable the IFRB and other Administrations to determine if such use is likely to cause harmful interference to any existing stations of other Administrations.

4.5.2 Advance publication

Five years before the bringing into service of an earth or a space station of a space system, the Administration concerned has to provide the IFRB with certain minimum essential information about the planned system. This information is published by the Board in a Special Section of its weekly Circular, and sent to all Administrations by airmail and, within a period of four months from the date of publication, other Administrations have to give their comments on the publication, if any of them consider that the interference which may be unacceptable may be caused to their existing or planned space services. The characteristics so published are for information only. No right dervies from their publication.

4.5.3 Coordination between space systems

After the procedure of advance publication is completed, the Administration responsible for the system has to request the agreement of Administrations, the space services of which may be affected, and to communicate the information concerning the space station to be located on a geostationary satellite, or an earth station that is to communicate with such a space station. The same information is sent to the IFRB for publication in another Special Section of the weekly Circular by the IFRB, together with the results of its assessment of the other space systems that are likely to be affected, so that the necessary coordination may be effected between the space systems concerned before the new system is brought into service. As from the date of this publication, the proposed use is protected against the interference that may be caused by any further use.

4.5.4 Coordination of frequency assignments to an earth station in relation to terrestrial stations

Before the proposed frequency assignment to an earth station, irrespective of whether it is to communicate with a space station on board a geostationary satellite or on board a non-geostationary satellite, is brought into service, the Administration responsible for the earth station has to coordinate each frequency assignment above 1 GHz to such an earth station, with its neighbouring countries, to ensure that the terrestrial stations of these countries, using the same frequency band, will not be adversely affected by or will not, in their turn, adversely affect the earth station.

4.5.5 Coordination of the terrestrial stations

After the coordination referred to in 4.5.4 above has been effected, the neighbouring Administrations have an obligation to coordinate their terrestrial stations, using frequencies above 1 GHz, to be located within the so-called coordination area around a receiving earth station, and using the same frequency band to ensure that there is no possibility of interference from the terrestrial station to the receiving earth station.

4.5.6 Technical bases for coordinations

The procedures of coordination referred to in 4.5.2 to 4.5.5 above have to be carried out by Administrations, using the methods of calculation for the evaluation of interference prescribed in Appendices 29 (for coordinations referred to in 4.5.2 and 4.5.3 above) and 28 (for coordinations referred to in 4.5.4 and 4.5.5 above). Appendices 28 and 29 to the Radio Regulations permit the determination of the necessity of coordination. However, the actual coordination to determine the technical measures to be taken to avoid mutual interference between systems and stations needs to be carried out on the basis of more precise technical information, either agreed to by the Administrations concerned or as given in the CCIR Recommendations.

4.5.7 Notification and recording of frequency assignments

The frequency assignment notices to stations of the space services have to be submitted to the IFRB after the coordination procedures mentioned above are completed, and before bringing the stations into use. The Board examines these notices to ensure that the notices are in conformity with the provisions of the Radio Regulations, including those relating to the coordination and, if it concludes that the necessary procedures have been successfully carried out by the notifying Administration, it records the frequency assignments concerned in the Master International Frequency Register. Such recording, when made, is also published in the weekly Circular of the IFRB, and thereby the international community is informed that the assignments concerned have acquired international recognition.

4.5.8 Other provisions of Articles 11, 12 and 13

These provisions are aimed at providing solutions in cases where one or more of the procedures cannot be successfully completed and the assistance which the IFRB is required to provide to the Administrations in completing such procedures. There are also other provisions in these Articles requiring that the IFRB maintains the Master Register up to date, and ensures that obsolete entries in the Master Register are removed therefrom.

4.6 Article 14 - Supplementary procedure to be applied where a footnote in the Table of Frequency Allocations requires agreement with an Administration

There are 56 footnotes of the Table of Frequency Allocations, more than half of which relate to allocations to specific space services, which require agreement to be reached under the procedures set forth in Article 14 between the concerned Administrations, before a frequency assignment of the service concerned can be considered to be in conformity with the Table of Frequency Allocations. Conformity with the Table of Frequency Allocations is one of the essential conditions to be satisfied by the assignment, without which the Radio Regulations do not permit the assignment concerned to enjoy the full rights flowing from the provisions of the Radio Regulations. The procedure of Article 14 requires the Administration responsible for the assignment to provide the Board with the essential particulars of the assignment in a prescribed form. On receipt of the information, the Board identifies Administrations whose services may be affected, and publishes the information, together with the list of such Administrations, in a Special Section of its weekly Circular. Any Administration which believes that the planned assignment subject to the publication may affect its services, existing or planned, is required to communicate its comments within four months of the date of the relevant weekly Circular. In the absence of such comments, it is regarded as unaffected by the planned assignment. The procedure, as described in the Radio Regulations, appears very simple but the Board has experienced considerable difficulties in its application, particularly to stations of the space services.

4.7 Article 15 and Appendix 30 to the Radio Regulations - Broadcasting-satellite service and other services in the 12 GHz band

Article 15 refers to the provisions contained in Appendix 30 which concern the Plan for the broadcasting-satellite service in the frequency bands 11.7 - 12.2 GHz in Region 3 and 11.7 - 12.5 GHz in Region 1, adopted by the World Broadcasting-Satellite Administrative Radio

Conference, Geneva, 1977. That Conference also adopted procedures to modify the Plan and the procedures to be applied by stations of other services to which these bands are allocated, so far as their relationship to the broadcasting-satellite service in these bands is concerned. These procedures are similar to the procedures of advance publication, coordination and notification, explained in paragraph 4.5 above, but they are additional to those procedures and have to be applied separately.

4.8 Article 27 - Terrestrial services sharing frequency bands for space services above 1 GHz

The provisions in this Article are aimed at protecting the geostationary-satellite orbit from interference from the terrestrial services. For this purpose, the maximum equivalent isotropic radiated power (e.i.r.p) of a station in the fixed or mobile service, in frequency bands allocated to space services for reception by space stations, is limited to a value of 47 dBW in any direction within ± 0.5° of the geostationary-satellite orbit, progressively increasing to 55 dBW in any direction ± 1.5° of the geostationary-satellite orbit. Furthermore, limits are also imposed on the power delivered by a transmitter to the antenna of a station in the fixed and mobile service in frequency bands above 1 GHz which is limited to +13 dBW up to 10 GHz and +10 dBW above 10 GHz.

4.9 Article 28 - Space services sharing frequency bands with terrestrial services above 1 GHz

To protect terrestrial services from interference from the earth stations, the e.i.r.p transmitted by any earth station towards the horizon is limited to 55 dBW in any 4 kHz band in frequency bands between 1 and 15 GHz, and is limited to 79 dBW in any 1 MHz band in frequency bands above 15 GHz. Furthermore, there are provisions whereby the earth stations shall not be employed for transmission or for reception at elevation angles less than 3° to 10°, depending on the purpose for which they are used. This Article also contains provisions whereby the power flux-density from space stations on the surface of the earth is limited in frequency bands used for transmission by space stations, so as to ensure adequate protection of the terrestrial services which use the same frequency bands with equal rights.

4.10 Article 29 - Special rules relating to space radiocommunication services

This Article contains provisions concerning measures to be employed by space stations, such as capability of cessation of emissions, station keeping, pointing accuracy of the antenna, which are meant to limit mutual interference between space systems and unintentional spill-over of radiation outside the service area of the space stations. It also contains provisions to protect the geostationary-satellite orbit from off-axis radiation by earth stations and those relating to the protection of radio astronomy observations and other users of passive services in the shielded zone of the moon.

4.11 Other provisions of the Radio Regulations relating to space services

Appendices 4 and 3 to the Radio Regulations contain the lists of technical parameters of the space system to be provided respectively for advance publication and for coordination and notification purposes. The WARC-79 requested the Board to develop the forms of notice for items listed in Appendix 3, whereby these notices can be treated by the IFRB with the use of the computer. There are other provisions contained in Articles 30, 32, 35, 36, 48, 57, 59, 61 and 66, which relate to individual space services, such as broadcasting-satellite service, amateur-satellite service, radiodetermination- satellite service, radio astronomy service and maritime mobile-satellite service.

4.12 Resolutions of WARC-79

The WARC-79 also adopted many Resolutions and Recommendations relating to space services. The Resolutions mainly cover those subjects for which the Conference did not think it appropriate to make provisions of a permanent nature in the Radio Regulations. They relate to provisional procedures which the IFRB and Administrations are required to apply until more definite provisions, based on experience, can be adopted and incorporated in the Radio Regulations at future world administrative radio conferences. Reference has been made earlier to some of these Resolutions, such as Resolutions Nos. 2, 3, 4 and 101 (see paragraphs 2.7.3 to 2.7.5 above). The Recommendations are generally addressed to Administrations and the CCIR, where the Conference identified need for further technical studies as inputs to future administrative radio conferences which will deal with space radiocommunication services, such as the forthcoming WARC-ORB Conference, to be held in two sessions in 1985 and 1988.

5. WORLD ADMINISTRATIVE RADIO CONFERENCES ON PLANNING OF THE GEOSTATIONARY-SATELLITE ORBIT

5.1 The WARC-79 adopted Resolution No. 3 relating to the use of the geostationary-satellite orbit and to the planning of space services utilizing it. The Resolution foresaw that the Conference shall be held in two sessions. The first session has to:

a) decide which space services and frequency bands should be planned;

b) establish the principles, technical parameters and criteria for the planning, including those for orbit and frequency assignments of the space services and frequency bands, taking into account the relevant technical aspects concerning the special geographical situation of particular countries, and provide guidelines for associated regulatory procedures;

c) establish guidelines for regulatory procedures in respect of services and frequency bands which are not planned;

d) consider other possible approaches to guarantee, in practice, for all countries equitable access to the geostationary-satellite orbit and the frequency bands allocated to space services.

The second session is required to implement the decisions taken at the first session.

5.2 Taking into account the provisions of Resolution No. 3 of WARC-79, as well as those of Resolution No. 8 of the Plenipotentiary Conference, Nairobi, 1982, relating to the planning of the feeder links for the broadcasting-satellite service operating in the 12 GHz band in Regions 1 and 3, the Administrative Council of the ITU, in consultation with the Membership of the Union, adopted Resolution No. 895, in which it decided that the first session of the Conference shall be convened in Geneva from 8 August 1985 for a duration of five and a half weeks. The main items retained in the Agenda are those contained in Resolution No. 3 of WARC-79 and Resolution No. 8 of the Plenipotentiary Conference, which are already mentioned above.

5.3 The Administrative Council also invited the CCIR to complete the necessary technical studies. The CCIR held a joint Conference Preparatory Meeting of its Study Groups from 25 June to 20 July 1984. The Report of this Meeting is published and has been distributed in early November 1984.

5.4 The Council also invited the IFRB to prepare a Report on the operation of the procedures contained in the Radio Regulations, including information about difficulties which may be reported to the IFRB by Administrations in gaining access to suitable orbital locations and frequencies, and to circulate this Report to Administrations at least one year before the first session of the Conference. The IFRB is also invited to carry out technical preparations for the Conference in accordance with the provisions of the Radio Regulations.

5.5 The ITU Conferences normally carry out the tasks prescribed in the Agenda of the Conference on the basis of the proposals received from Administrations. In accordance with the provisions of the Convention governing the administrative conferences, the proposals have to be submitted by Administrations to the Secretary-General of the ITU well in advance, to enable him to translate and distribute them at least four months before the opening of the Conference. Such proposals are expected to take into account the Reports of the CCIR and the IFRB and, of course, the interests of each country which makes proposals. The Conference itself divides these proposals according, to their subject matter, into specific groups and assigns them to Committees, where the proposals are discussed in detail and a concensus reached, so as to provide least dis-satisfaction to all in fulfilment of the tasks assigned to the Committees within the framework of the Agenda of the Conference.

5.6 Proposals from Administrations for the first session of the WARC-ORB have not yet reached the ITU and it is rather early to make any guesses as to the nature of the proposals that may be submitted.

INTERNATIONAL POLICY ISSUES IN SATELLITE COMMUNICATIONS

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Abstract

After two decades of rapid development, the global communications satellite pattern is about to undergo massive changes. A number of critical policy issues will have to be resolved, most notably the future role of Intelsat, the 109-member satellite consortium. A number of commercial firms are challenging its status as the "chosen instrument" global carrier. Another issue is the attempt of Third World countries to promote rigid planning of radio frequencies and geostationary orbital slots for satellites.

After twenty years of rapid expansion, the global satellite pattern is undergoing massive changes at all levels - technical, operational, economic and political. These changes, in turn, raise a new set of policy issues. This survey will review some of the major issues and their potential effect on the future of world satellite communications.

To understand the changes, it is useful to remember that satellites reversed the usual procedure by which telecommunications networks are set up. Normally, a network starts small and expands outward as demand increases. Because of their technical characteristics, however, satellite networks developed differently. Almost from their inception in the early Sixties, the satellites formed a global network. Expansion has taken place within this worldwide pattern.

From now on, satellite policy issues will focus increasingly on the pattern of "local" satellite networks, whether the locality is a large geographical region or an individual country. This paper will consider these factors from the standpoint of the opportunities and barriers involved in making more effective use of satellites in the coming years.

First, a review of where we stand now in world satellite communications development. Despite all the current changes, the fact remains that, for the present, almost all global satellite operations involve just one organization. Intelsat the 109-member consortium, is the cornerstone on which most international satellite activities will be based for a long time to come. Policy issues revolve largely around the role of Intelsat in a changing pattern. Intelsat has been the leader in pioneering what was so recently a vast, unknown potential. It has persistently moved ahead in developing global satellite services, but not without the problems that come with success.

The organization has revolutionized world communications since it began network operations twenty years ago. Starting with about 250 circuits in 1965, its capacity has grown to over 43,000 circuits worldwide, with plans for an increase to over 65,000 in 1987. Intelsat currently operates a seventeen-satellite network, from which it earned $300 million in 1982. Its average annual rate of return on capital has been 16 percent. Moreover, it is in the midst of a $2 billion program to build its sixth generation of satellites.

If Intelsat had not developed as an integrated global system, we would probably be dealing with an inefficient pattern of disjointed regional and national systems. Fortunately, this is not the case. Satellites are ready to play a key role in integrating global telecommunications development in the coming years - an expansion that will involve $800 billion in telecommunications expenditures, or twice as much as total OPEC oil surpluses in the past decade.

In the present re-examination of satellite policy issues, the abiding fact is that Intelsat has performed successfully. Moreover, its 109 member-nation owners are committed to maintaining the network as the chosen-instrument global system. Since these countries are responsible for over 95 percent of all world communications, the commitment is a significant one. Also significant is the fact that Intelsat enjoys the stability of international treaty status. Article 14 of the basic Intelsat agreements was approved by its members in 1972 when the organization's permanent arrangements were concluded, and by all countries which have joined the organization since then. Stripped of its legalese, Article 14 puts limits on the entry of any competing systems which threaten the economic viability of the basic Intelsat network.

Article 14 was intended primarily to protect Intelsat's ability to develop as an integrated chosen-instrument world system. This concept is now being challenged. The challengers question whether Intelsat should continue to be protected against outside competition. Such competition, in their view, could supply a wider range of specialized services. They argue that Intelsat has evolved as a global cartel, dominated by PTT organizations whose primary interest is to assure themselves continued control over profitable international circuits. Rene Collette, chief of the European Space Agency's satellite department, reflects this view when he says that Intelsat's monopoly over inter-continental satellite traffic is no more defensible than a monopoly of trans-Atlantic air traffic would be.

Mr. Collette and other challengers have pressed their point vigorously. On the other hand, Intelsat was created (largely through American pressure) with the specific intention that it have a dominant position in international communications in order to assure an integrated global system. Whether or not the organization is a PTT-dominated cartel, as charged, is in the eye of the beholder.

Intelsat's defenders argue from success. They point out that, whatever the motives of the PTT's, the system has worked efficiently. Intelsat has, for instance, reduced its charges for overseas telephone circuits by more than 90 percent (adjusted for inflation) in twenty years - not a bad record.

In summary, Intelsat is the primary factor in any decisions on the future of international satellites. The erosion of its monopoly position in this field is already in process. It began several years ago when the organization's Board of Governors agreed, under Article 14 provisions, to allow the Indonesian government to provide regional telecommunications services over its domestic Palapa-B satellite to Malaysia, the Philippines, Singapore and Thailand. The Board has also given permission to a group of Arab states to operate a regional satellite network which will have a 'footprint' extending from North Africa to the Persian Gulf.

The Board has made a somewhat similar decision in connection with a European regional satellite network based on a determination that traffic on the network would be diverted from regional terrestrial networks rather than from the Intelsat system. In another case, the United States and Canada agreed in 1982 to bilateral arrangements for transborder satellite data traffic under the Article 14 umbrella. The Federal Communications Commission (FCC) is currently processing 29 applications for the use of American domestic satellites in transborder operations involving Canada, the Caribbean and Latin America, pending final Intelsat Board of Governors' approval under Article 14.

Each of the above cases involves limited regional satellite links, none of which should harm Intelsat's overall economic viability as a global "carrier's carrier." In the next half-dozen years, there will be other regional and bilateral arrangements in all parts of the world conforming to this pattern. The real pressure on Intelsat's near-monopoly position in international satellite network is just beginning. Technical advances such as spot beams and inter-satellite links make possible the use of non-Intelsat systems for intercontinental communications - the backbone role currently reserved for Intelsat.

This exclusivity is now being directly challenged by commercial firms which want to compete with Intelsat in the profitable traffic markets, particularly the North Atlantic region. The future high-density characteristics of North Atlantic traffic were underscored in 1983 projections made by AT&T and CEPT (the European PTT consultative group). Their estimate of total telephone and record traffic requirements for 1985 is 19, 516 circuits with a five-fold increase to almost 98,000 circuits by 1995.

The prospect of commercial satellite firms getting a competitive piece of this expanding business dominates the issue of Intelsat's future as a monopoly intercontinental carrier. In 1983, two U.S. firms applied to the FCC for permission to construct, launch and operate satellites designed to provide trans-Atlantic communications circuits which would by-pass Intelsat facilities. The first to apply, Orion Satellite Corporation, proposes to sell transponders to individual users, with the expectation that they will utilize customer-premise earth stations. In its filing, Orion declared that the Article 14 restrictions on common carrier competition to Intelsat do not apply to its proposed service. The firm argues that its target market is not common carrier traffic but corporate users wanting private dedicated data and video transmission.

The second firm to apply, International Satellites Inc. (ISI), proposes to sell at least half of its spacecraft capacity to individual firms, reserving most of the rest for common carrier services at tariffed rates. Meanwhile, during the past year, a number of other firms have applied to the FCC for permission to compete commercially for North Atlantic satellite business.

U.S. government agencies have been split into at least two camps on the issue of commercial competition to Intelsat. By and large, there is agreement on the desirability of some competition; the differences involve the level of competition that should be permitted.

Those who support limits on competition to Intelsat point out that the United States has a major stake in the organization's continued viability for both political and economic reasons. At the strategic level, they argue, it is in the American interest to maintain an integrated global system, for reasons that include the possibility of a Soviet attempt to compete actively with a weakened Intelsat, particularly in Third World regions. (The

Soviet threat is, for the present, minimal, with only a few hundred telephone circuits operational in its worldwide Inter-sputnik network, compared to Intelsat's 40,000-plus).

The proponents of greater competition see the Orion, ISI and other proposals as logical extensions of the U.S. domestic "open skies" satellite pattern, with its success in creating a wide array of competitive services during the past decade. Intelsat, they argue, is strong enough economically and operationally to withstand new competition. They defend Orion and ISI against charges of potential cream-skimming of the intercontinental market on the grounds that global telecommunications expansion in recent years proves that there is enough business for everyone.

Meanwhile, as of the end of 1984, the issue remains unresolved. Within the U.S. government, a basic policy determination has been blocked by differences among the key agencies. Within Intelsat, most member-governments are on record against granting Article 14 permission for Orion-type operations. At the 1983 Intelsat Assembly of Parties meeting, the United States pledged not to take any actions which would be harmful to Intelsat. The phrasing of the pledge could be viewed as containing a certain amount of creative vagueness. The vagueness reflects the fact that any U.S. government decision in the matter will involve not only the Federal Communications Commission, but also the Departments of State and Commerce, the Congress, and the White House. Given this mix of players, each with slightly different interests, any decision will require some compromise. A final determination will probably allow one or more of the competing proposals to be approved, in a package that will include assurances to Intelsat that its economic interests will be taken into account. It then remains to be seen whether Intelsat's other members will accept the proffered assurances and approve the arrangement under the Article 14 provisions.

The Intelsat organization has meanwhile taken steps to match the potential competition. Under the leadership of its new Director-General, Richard Colino, it is offering a variety of new services paralleling those of possible competitors. Its most direct action has been to expand its services in the business communications area. The organization's new International Business Service (IBS) provides a range of fully digital communications services, including video, teleconferencing, high and low speed facsimile and data, and electronic mail. In recent months, it has inaugurated a service, known as Intelnet, which will permit users to transmit data-base information to small earth stations on customer premises worldwide.

A number of American firms have moved quickly to supply links to these new services. International Relay Inc. is proceeding with plans to operate earth stations in a number of major metropolitan areas which will provide business services on Intelsat circuits. Satellite Business Systems, with IBM as its majority owner, has been given similar FCC permission to access the Intelsat network directly in order to provide its customers with IBS services.

If the new commercial challengers are allowed to compete with Intelsat on international routes, they will have their work cut out for them in establishing a viable niche in the business. Not the least of their problems will be to convince old-line conservative European PTTs to link up with their services. Both Orion and ISI claim that the Europeans have indicated a willingness to do business with them.

One prospect that faces both Intelsat and its potential commercial competitors is the possibility of circuit overcapacity in the North Atlantic and other high-traffic areas. Satellite circuit use has expanded dramatically every year in these areas. So far, Intelsat has been able to adapt its own operational capacity to meet these needs. With the potential introduction of competitive satellites, the question of overcapacity, and its subsequent economic effects, will be a concern. The issue is complicated by the introduction, before the end of the decade, of the first fiber-optic submarine cable linking North America and Europe. The new cable will have substantially greater capacity than the present coaxial cables, resulting in a considerable increase in trans-Atlantic circuit capacity. Two U.S. venture firms have applied to the FCC in recent months to operate fiber optic cable systems in the North Atlantic.

A related issue is the current re-examination of the U.S. government's twenty-year-old policy of mandating equal use of satellite and cable facilities by American international carriers. The policy, originally intended to assure the economic viability of both types of circuits, has been challenged as outmoded in the new pro-competitive telecommunications environment. If the restraints are lifted, a likely result could be a shift in traffic patterns favorable to cables for reasons involving the way in which AT&T and other carriers determine their rate base and subsequent profits.

Another set of satellite issues involves the developing nations. In the coming decade, Asia, Africa and Latin America will be prime areas for satellite expansion. Third World countries have generally been strong supporters of Intelsat because it has linked them efficiently with the industrialized North and also with each other. As noted earlier, developing nations are also planning supplemental regional satellite networks. Such systems are already active in Southeast Asia and in the Middle East. Others are on the drawing boards. About two dozen developing countries are presently leasing circuit capacity from Intelsat for their domestic communications.

The growing interest in satellites by Third World countries has led to a problem which could have serious long-range effects on the current swift pace of expansion of the world system. It stems from the Third World's desire not to be left behind in satellite development, and particularly their aspirations for operating their own systems rather than relying on Intelsat or on commercial Western networks.

The hard fact is that few developing countries have the resources to put up their own satellites, although a few have done so, notably India and Indonesia. Brazil and Mexico each have active plans for their own domestic networks. (The Brazilian satellite will be financed, in part, by barter deals involving coffee). Other developing countries will rely on jointly-owned regional satellite networks to meet expanding satellite needs.

Impeded as they are by financial barriers, Third World countries worry that they will lose the race for access to radio frequencies suitable for space communications and for geostationary orbit (GSO) slots - the satellite "parking spaces" above the Equator. Until now, these resources have been assigned, within the International Telecommunications Union system, on essentially a first-come, first-served basis. Industrial nations, notably the United States and the Soviet Union, have benefited from this system, registering large numbers of frequencies and orbital slots with the ITU.

Third World nations protest that this process works against their long-term interests. They are no longer willing to accept general assurances that spectrum and orbit resources will be available to them when they are ready to enter the satellite business. Instead, they are now proposing modifications of the ITU first-come, first-served procedures. Specifically, they would replace these procedures with some type of planning mechanism that would pre-assign space frequencies and orbit slots country-by-country so that every nation would have an *a priori* claim on specific resources, whether or not it plans to develop a satellite capability in the future.

In a worst-case scenario, such a solution could result in severe limitations on the ability of advanced industrial countries to continue their rapid expansion of satellite facilities. The frequencies and orbit slots they may need could be unavailable to them if they are pre-assigned under ITU regulations to countries which might, in fact, never have use for them.

Coming up with an acceptable compromise will be the main issue before the ITU "Space WARC" conference, scheduled to meet in two sessions next August and again in 1988. There are, fortunately, workable alternatives to rigid planning of frequencies and orbital slots which can provide adequate safeguards for all countries, now and in the future. These alternatives involve new forms of flexible planning for future satellite needs in ways that will provide the most efficient use of spectrum and orbit slots. There is serious consideration being given to planning regimes which would give every country an equal minimum amount of frequencies and GSO slots. Remaining resources would be put into a common pool, to be drawn on only as individual countries (or multi-user networks like Intelsat) actually have use for them.

It is too early to determine whether a consensus on this, or a similar compromise, will be reached at the conference's first session later this year. The United States is already advanced in the preparation of its proposals for the meeting; most other countries are well behind.

The basic issue of competitiveness remains undecided. Its resolution will depend on whether a significant number of Third World countries are willing to accept some form of guaranteed assurance of access to frequency and orbital resources short of rigid pre-assignment of these resources. The issue is more political than technical. It involves moderating current Third World suspicions about "electronic imperialist" domination of global communications resources by the industrialized nations.

There is not much time for the United States and its industrial allies to come up with a workable strategy for this year's session of the conference. Not only do they have to agree among themselves on a set of realistic proposals, but they must also be prepared to convince a significant number of developing countries to accept them. For the present, the prospects for achieving this are mixed at best.

THE ROLE OF STANDARDS IN A COMPETITIVE TELECOMMUNICATIONS ENVIRONMENT

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Abstract

As the telecommunications industry is deregulated, standards play an increasingly important role. In a competitive market, standards serve as a basis on which producers can compete. They benefit both producers and consumers of equipment and services.

In the United States, the Federal Communications Commission has, on some occasions in recent years, declined to set standards, opting instead to "let the market decide." A competitive market, however, is based on identical or nearly identical products and on perfect or nearly perfect knowledge on the part of the consumer. These economic principles, along with examples from the recent past, are used to make a case for the importance of standards.

INTRODUCTION

For many years in the United States, the Federal Communications Commission (FCC) set technical standards for broadcast services. Standards for color television and FM stereo, for example, were established by the Commission before these services became standard offerings. With a technical standard in place, equipment manufacturers and broadcasters were able to move forward with the development of each service, and consumers were able to buy equipment without confusion and without concern about compatibility.

In recent years, however, the FCC has shown an unwillingness to continue its standard-setting role. Two notable examples are the Commission's AM stereo and television stereo decisions. In both cases, the Commission authorized the new services but declined to set a technical standard, opting instead to "let the market decide." Thus, broadcasters, equipment manufacturers, and consumers have been denied the assurance that these services can develop without compatibility concerns.

The Commission's new allegiance to "the market" is part of the trend in the United States toward deregulation and the introduction of increased competition in telecommunications. The shift began in the common carrier area, with the decision to allow long lines carriers to operate in competition with AT&T. A major court decision (The AT&T divestiture decision) and a long series of FCC decisions have led to extensive competition in the long lines common carrier area; the authorization of a number of new services; relaxation of restrictions on broadcast services like cable television, low power television, and direct broadcast satellite television; and relaxation of a number of regulations governing FCC licensees. All of these changes have been based on the assumption that "natural" competitive market forces serve the public interest better than "unnatural" regulation.

The same reasoning led the Commission to its decisions not to decide recent standards questions. BUT, does the lack of a standard enhance or inhibit the operation of market forces when new products or services are being introduced? Could it be that the adoption of standards enhances the market forces on which the FCC has come to place great reliance?

COMPETITIVE MARKETS

Since the theory of competitive markets has played a key role in FCC decisions, let us examine such markets. According to classical microeconomic theory, "pure" competition has the following attributes: (1, 2)

-- Each buyer and seller in the market buys or sells a small quantity of product or service relative to the overall size of the market. The product is homogeneous, and, since each market participant trades only a small quantity, he is unable to affect the market price.

-- No artificial restrictions are placed on supplies or demands of products or resources. Further, there are no restrictions on prices.

-- Products and resources are perfectly mobile. Firms are free to enter or leave the market at any time.

"Perfect" competition, by an economists' definition, has all of the above characteristics, and, in addition: (1, 2)

-- All buyers and sellers have complete knowledge of the market at all times.

It is clear that real markets rarely, if ever, qualify as either purely or perfectly competitive. Economies of scale result in smaller numbers of sellers. Consumers want variety. Governments place artificial restrictions on markets in order to pursue overriding social goals. Government regulations and other realities restrict market entry. Buyers and sellers typically have very limited knowledge of the markets in which they participate. (2)

Although natural market forces are seldom completely free to operate, many who have examined telecommunications regulation in the United States have concluded that the regulatory process has been even less efficient than markets which operate imperfectly. Indeed, many American consumers have already benefited from lower long distance telephone rates and access to an abundance of broadcast services. Thus, increased competition linked with reduced regulation may be a net gain for the American consumer.

THE RELEVANCE OF STANDARDS

If we are to place increased reliance on the efficient operation of competitive markets, it would appear to be wise to insure that these markets operate as efficiently as possible. One of the attributes of pure (and perfect) competition is that products are homogeneous; that is, they are standardized. In telecommunications, compatibility is of particular interest. If products are compatible, they can be substituted for each other easily, and if this is the case, buyers will be able to make their purchase decisions based on such issues as performance, reliability, and, most importantly, from an economists's perspective, price. Buyers of equipment include both providers and consumers of telecommunications services.

Let us imagine, for a moment, the introduction of a new line of broadcast equipment and associated services for which a standard exists. Service providers are able to make market decisions based on their assessments of demand for the service and the cost of providing the service. Consumers can make decisions based on the cost of equipment, equipment performance, and the desirability of the services being offered. Equipment manufacturers can make decisions based on their demand projections and on the cost of manufacturing and distributing the equipment. None of the players need be concerned about purchasing equipment which will later become obsolete because some incompatible equipment has gained market dominance. Natural market forces are at work.

Now imagine the introduction of a new line of equipment and services for which no standard exists. Equipment compatibility must be a major concern of all parties and this concern will clearly inhibit the growth of this market. This market is not operating as efficiently as it might.

This is more than just a theoretical argument. Following its introduction in the United States, AM stereo, without a standard, does not appear to be developing nearly as well as did FM stereo, with a standard. Quantitative histories of the development of these two services would, I believe, reveal the importance of standards.

STANDARDS ORGANIZATIONS

Who should set standards? In the United States, the FCC appears to have opted out of this function, leaving a void, at least in the short term. In the long term, the Commission's withdrawal may not be a bad thing. A regulatory body must take great care to see that every matter is handled in accordance with the legal requirements of due process. This due process is one reason for the long delays which have come to be known as "regulatory lag." Further, it is not clear that due process is an efficient way to produce a technically correct solution.

There are a large number of standard setting organizations today which are part of professional or trade associations or are cooperative efforts involving interested firms. Such groups function knowledgeably and efficiently in many product areas, including telecommunications. While compliance is voluntary, this standards activity is generally quite effective.(3)

A recent announcement indicates that a new committee has been formed to foster technical standards for advanced television systems in the United States. Such television systems include high definition television, a new service for which no standard presently exists. The new committee, called the U.S. Advanced Television Systems Committee, was created by the Joint Committee on Inter-Society Coordination, which was, in turn, created by the Institute of Electrical and Electronic Engineers, the Electronic Industries Association, the National Association of Broadcasters, the National Cable Television Association, and the Society of Motion Picture and Television Engineers.(4) Three of these are trade associations and two are professional associations. It will be interesting to follow the activities of this group. Perhaps it, or groups like it, will soon fill the void left by the FCC.

CONCLUSION

The FCC, in deregulating the telecommunications industry in the United States, seems to be abdicating its role as a setter of technical standards. The Commission is apparently unaware of the importance of standards.

Actually, the rise of competition heightens the importance of standards. The theory of competitive markets stresses the importance of standardized products and services. In real markets, which are imperfect, standards make market operation less imperfect. They eliminate compatibility concerns as an inhibitor of proper market operation.

If the FCC is to opt out of telecommunications standards activity, this function may be assumed by professional and trade associations. Such groups set technical standards in a number of other areas.

NOTES AND REFERENCES

1. Richard H. Leftwich, The Price System and Resource Allocation, pp. 23-25. New York: Holt, Rinehart and Winston, 1963.

2. Alfred E. Kahn, The Economics of Regulation: Principles and Institutes, vol. 2, p. 114. New York: Wiley, 1971.

3. Standards activity is not without hazard for professional associations. In 1982 the U.S. Supreme Court found that the American Society of Mechanical Engineers (ASME) was responsible for the actions of some of its members who used ASME standards procedures to violate antitrust law. Since this decision, many professional societies have been revising procedures in order to avoid similar liability. See Tekla S. Perry, "Antitrust Ruling Chills Standards Setting," IEEE Spectrum, vol. 19, no. 8, pp. 52-54. August 1982.

4. Ronald K. Jurgen, "The Problems and Promises of High Definition Television." IEEE Spectrum, vol. 20, no. 12, pp. 46-51. December 1983.

Standards Needed for International Digital Telecommunications

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Abstract

International Standards toward an ISDN have been under study in CCITT during the last Study Period, and many pertinent Recommendations relating thereto have been adopted. Where the user may interconnect his terminal, or even his own extensive private network, has been under study during the same period in ISO, and in the combined sessions of Experts from both Bodies. An overview of the approved Standards and Recommendations and those likely to come soon is presented. New devices and technologies which accelerate these services are identified, and the value of standards in system synthesis and access to networks is described.

1. INTRODUCTION

Four years ago I was able to report to the PTC 81 the results of the Plenary of the VIIth Study Period of CCITT. I was one of a team of four dealing with aspects of International standardization activities in the ISO, IEC, and CCITT. While my role at that presentation concentrated on ISO activities, and Mr. MacDonald of Canada, the Chairman of Study Group VII, handled most of the commentary about CCITT, the presentation was an integrated one. During the time of the VIIIth Study Period, which has just ended with a Plenary in Malaga-Torremolinos last October, a number of significant relationships have evolved, and these are important to the ISDN. On one hand, under the coordination of Study Group XVIII, many CCITT Study Groups - VII and VIII in particular, followed closely by XI and XVII - have produced many significant Recommendations and have posed Questions for study in the new (1984-1988) period. Within the ISO, a major event early in the 1981-1984 time frame has been the establishment of a subcommittee of TC97 on Text and Office Systems: TC97/SC18. This Committee is an outgrowth of the restructuring of TC97 to absorb TC95. Another major effect, occuring late in this time frame, is still in process of initial implementation. It is the division of TC97 into three groupings; in the Systems Grouping are SC18, joined by SC6 (of which I am Chairman) newly created SC21 and SC22, along with the Sub Committee of which CCITT has had the longest association, namely TC97/SC2, Codes and Character Sets.

Another major event in the 1981-1984 time period was the formation in ISO of a group on Industrial Automation: TC184. Taking the elements of SC8 and SC9 from TC97 and likely to borrow a number of the technologies of TC97/SC6 and TC97/SC21, at least. In another segment has been the efforts and progress in IEC. The Committee of Action established TC 83 dealing with Information Systems Equipment, in Rio de Janiero in 1982. This body has looked at a number of areas of activity: the work on LAN's going on in TC97/SC6, the possible standardization of Home Electronics Systems, which has resulted in the creation of Working Group 1 of TC83. WG1 held their first technical meeting two months ago. IEC also created TC84, the program of work of which is still in the formative stage. In this presentation, I will attempt to describe those accomplishments in greater detail and relate them to the application to the Pacific Basin from the standpoint of suppliers of communications facilities, of the suppliers of Information Systems, the entities of the region and the users.

2. THE OBJECTIVES OF ISDN

When the words "ISDN" were mentioned some five or six years ago, it raised images in the minds of each of the standardization sectors mentioned above. As it evolved, these images have been more or less fulfilled but nevertheless, the results are somewhat surprising or unanticipated by the co-holders. For instance, from the viewpoint of the various common carriers in both developed and developing countries, they have seen an opportunity to merge or provide transition from the facilities they have had to a series of networks of digital telecommunications facilities, which would carry voice, data and video services. In some entities, these services may not have been existent or may still not be existent at the time of an ISDN adoption individually. In other entities there is the possibility that data was passed only on voice circuits, and video channels were very limited. There are problems in multiplexing and synchronization which had to be faced in the environment that had not existed earlier. And while the solutions exist technically, there is considerable impact on the implementation of these changes.

As a taxicab earns no income until it gets passengers, so the all-digital network earns no money for the carrier until he gets traffic. Traffic comes in two forms: one is from the carrier-provided services and the other from independent connection of private terminals to the network, the traffic terminating either in public or other private connections. In terms of carrier provided services, there have been facsimile, (in fact, until not too long ago, CCITT called it facsimile telegraph!) There have been teletex, (which for some administrations represents a higher speed, more versatile successor or expansion of telex) and videotext. These services have developed on initiatives in a number of countries, the initiatives have been both private and also public; that is, through administrations. The point here is not public versus private, but independence action between services and between countries, with the result that some of the controls and accesses for the several services have not been compatible. A number of the Recommendations that we will describe below deal with the transition toward compatibility and additionally toward the integration of broadcast services involving the CCIR and Commercial Broadcasters. The issues for developed countries become more economic than technical.

An example of this is Recommendation T.62 where, in the previous Study Period, there have been extensive implementations in Canada and US as well which are incompatible with the French implementation. With economic impact, these three services must eventually become convertible or compatible. On the side of private connection, the initial investment in private data terminal devices is a significant factor in the decision that each operator must face with regard to providing a conversion device, a multiplexing device or scrapping his current terminal and replacing it with one that fits the new service. I don't wish you to get the impression that ISDN is the creation of an economic disaster for all current operations. Far from it. But I do wish to impress upon you the need to view facilities and operations planning on a long-term basis. I am convinced that ISDN is necessary for the 1990's and beyond. How to get there is the problem and we need mature judgments based upon expenses and benefits every year of at least a 10-year period. Some of the kinds of questions that face the DTE operator relates to the kind of device he has and the kind of transmission speeds that are most confortable and efficient for that device. Screen based terminals with high refresh rates and distributed memories would like to operate at connection speeds of the 50-60 kilobit per second range, as a minimum, regardless of how many bits per hour might be transmitted. On the other hand, voice networks of 1200 baud or lower speeds might very well benefit from rates in the 30 or even 15 kilobit per second range.

The carrier facilities provider looks at the four letters and says, "I, S (integrated services): here's a source of revenue from me." The DTE operator and private network builder says, "Well, I am now getting my digital service and I can get rid of the digital conversion devices and the speed limitations and distortions that they impose". The governments see the letter "N" as a mixed blessing, problems of how to connect networks, inter- and intra-country, and how to arrange for revenue splits and deal with the problems of accessing and charging for calls not completed, and other features.

I mentioned Local Area Networks (LAN's) momentarily above. As you might remember from my presentation last year, I offered LAN's as a benefit to dispersed communities, as means of providing interconnection of different kinds of services and different kinds of communications. These would be available in the near future for people with those disbursed kinds of problems and no facilities at hand right now, as well as being of service to the large commercial establishments where many stations are needed to carry out their business. These would occur in tourism: in terms of reservations, hotel operations, sports bookings, inventory control etc. The LAN standards, for some applications, are now available. Others are rapidly developing which provide a better opportunity to integrate more diverse services. Concurrent are the LAN problems of universal addressing: addressing that carries over regardless of which network you might be connected into and addressing which deals with a work station which might be transported and connected at different places by its owner/operator, as he goes about his business from home to office, from one island to another. In addition to the variations in these new facilities, digital improved multi-plexing, switching standards, etc. transmission media for a number of applications are also changing. The use of fibre optic links and fibre optic connections are helpful in providing wide bandwidth for a number of kinds of LAN's and other things. And new connectors, to make easy relocation of terminals, are in the midst of current standardization activity.

3. ACTIVITY IN CCITT SG XVIII

During the 1981-1984 Study Period, SG XVIII addressed the Questions assigned to it. Some of these Questions were more general than ISDN. Table 1 shows the Recommendations produced in response to these Questions, in the form accepted at the last (May 1984) meeting of the SG. They are all in the G series; if there is a small letter rather than a number in the unit or tens place, this is a new Recommendation. Additional new non-ISDN specific Questions which probably will not result in Recommendations in the G series - are in Table 2.

NEW AND MODIFIED NON-ISDN SPECIFIC RECOMMENDATIONS OF CCITT STUDY GROUP XVIII.

G.703 - Digital Transmission Systems; Terminal Equipments - General Aspects of Interfaces

G.70x - Digital Hierarchy Bit Rates (Four levels defined for the 1544 kbit/s and the 2048 kbit/s hierarchies)
G.70y - Functional Characteristics of Digital Interfaces (Frame structures, use of derived channels, bit sequence independence)
G.70z - Termination of Digital Paths on a Digital Exchange

G.711 - Pulse Code Modulation of Voice Frequencies (Modifications to A-law/u-law conversion tables)

G.722 - Interconnection of Digital Paths Using Different Hierarchies (Approved digital rates of 2048-6312 - 44736 - 129264 kbit/s between networks based on the 1544 kbit/s and the 2048 kbit/s hierarchies).

G.737-739 - Primary PCM Multiplex equipment; Synchronous Digital Multiplex Equipment; External Access Equipment (respectively) operating at 2048 kbit/s

G.7x2 - 60 Channel Transcoder with 32 kbit/s ADPCM coding

G.7zz - 32 kbit/s ADPCM Coding Algorithm (Specification of the 64 kbit/s PCM to 32 kbit/s ADPCM algorithm)

G.811 - Timing Requirements at the Outputs of Reference Clocks and Network Nodes for Plesiochronous Operation of International Digital Links

G.821 - Error Performance of an International Digital Connection of ISDN.

G.822 - Controlled Slip Rate Objectives on an International Digital Connection

G.82x - Control of Jitter and Wander
G.82y - Within Digital Networks Which Are Based on 2048 and 1544 kbit/s Hierarchies

TABLE 1

NEW QUESTIONS FOR CCITT SGXVIII, 1985 - 1988 NON - ISDN SPECIFIC

Definition of Parameters at the Network Side of NT Equipment.

Characteristics of Digital Sections
What changes to existing Recommendations (e.g., G.921) are required considering: bit rates, section lengths, performance objectives, propagation problems on radio relay digital paths.

Interworking Between Digital Systems Based on Different Standards

General Aspects of Interfaces in Digital Networks

Network Aspects of Existing and New Levels in the Digital Hierarchy

Networking Considerations of PCM/ADPCM Transcoding Equipment
What should be the network capabilities, the network signalling considerations, the networking characteristics and the performance of 32 kbit/s ADPCM transcoder equipment?

PCM Coding Laws According to Recommendation G.711

Digital Circuit Multiplication (e.g. low-rate speech coding and DSI)

Speech Analysis/Synthesis Techniques
Is there a need to define a standard analysis/synthesis algorithm at rates less than 10 kbit/s, and if so, what algorithm should be recommended?

Speech Packetization
What performance requirements and network constraints should be considered, and what algorithms, bit rates and packetizing techniques should be used?

32 kbit/s Speech Coding
Is an improvement in the ADPCM algorithm necessary, are there interactions between 32 kbit/s ADPCM and processes such as DSI and echo cancellation, or any effect of large d.c. offset on performance of 32 kbit/s ADPCM?

Wideband Speech Coding for 64 kbit/s Digital Paths

16 kbit/s Speech Coding

TABLE 2

More importantly, there are a number of ISDN specific Questions that SG XVIII will address, as shown in Table 3. Since SG XVIII is the coordinating unit for ISDN, it has formulated some Questions for SG XV to treat. These generally are more equipment oriented than the Questions listed in Table 2, as indicated in Table 4. While all of the above indicates much work in the future, there has been much accomplishment in the last Study Period. Table 5 lists the I series Recommendations that have been achieved.

NEW ISDN QUESTIONS FOR CCITT SGXVIII, 1985 - 1988

Definition of Service Principles

ISDN Architecture Functional Model

ISDN Protocol Reference Model
How should the X.200 Series and I.320 evolve?

ISDN Connection Types
What modifications are required to existing connection types (I.340) and what additional types should be identified?

ISDN - ISDN Internetwork Interfaces

Interworking of ISDN's and Other Networks

Numbering and Addressing Principles

Charging Capabilities in an ISDN
What characteristics and service capabilities could have an impact on charging and tariff principles, and what are the network implications?

ISDN Routing Principles

What ISDN routing principles should be recommended for communications between ISDN users and between ISDN users and non-ISDN networks.

General Aspects of User Network Interfaces

What new or modified Recommendations are required concerning principles of user - network interfaces?

Layer 1 Characteristics of ISDN User - Network Interfaces
Complete Recommendations I.430 and I.431, and consider interfaces using optical fibres, rates other than basic and primary and different applications and line codes.

Group of Questions on the Quality of Service and Performance of Digital Networks Including ISDN's
- M.1 - General Aspects
- M.2 - Performance Objectives For Errors and Short Interruptions
- M.3 - Performance Objectives for Timing and Controlled Slips, Jitter, Wander and Propagation Delay
- M.4 - Call Processing Performance
- M.5 - Availability Performance

TABLE 3

NEW QUESTIONS (FROM CCITT SG XVIII) FOR CCITT SGXV, 1985 - 1988

Digital Circuit Multiplication Equipment
What should be the recommended design characteristics of DCM equipment to meet identified attributes, including operation in an ISDN?

Characteristics of PCM Multiplex, ADPCM Multiplex and Other Equipments For Voice Frequencies
What new or modified Recommendations and equipments are required, considering synchronous digital access to multiplex equipment operating at 1.544 Mbit/s and 6.312 Mbit/s.

Characteristics of Digital Multiplex Equipment and Multiplexing Arrangements for Telephony and Other Signals
What new or modified recommendations should be made concerning multiplex equipment using justification, synchronous operation, higher bit rates (above 44736 kbit/s or 97728/139264 kbit/s) and use of service bits.

Characteristics of 32 kbit/s ADPCM/PCM transcoding equipment
What new equipment should be recommended, particularly at 1.544 mbit/s and what should be the performance characteristics; what compatibilities with other equipment exist?

Performance Characteristics of PCM ADPCM Channels at Voice Frequencies
What are the voice frequency characteristics of PCM and 32 kbit/s ADPCM equipment for 4-wire and 2-wire interfaces and for local network and telephone instrument interfaces?

Terms and Definitions for Digital Transmission
What terms and definitions should be recommended and what designations should be used?

TABLE 4

SOME OF THE KEY ISDN RECOMMENDATIONS IN THE NEW I-SERIES FROM CCITT STUDY GROUP XVIII

Service Capabilities

I.210 - Principles of Telecommunications Services Supported by an ISDN
I.211 - Bearer Services
I.212 - Teleservices

Overall Network Aspects & Functions

I.310 - Network Functional Principles
I.320 - ISDN Protocol Reference Model
I.330 - ISDN Numbering and Addressing Principles (E.164)
I.340 - ISDN Connection Types

User - Network Interfaces

I.411 - ISDN User-Network Interfaces - reference configurations
I.412 - ISDN User-Network Interfaces - channel structures and access capabilities
I.430 - Basic User-Network Interface - Layer 1 Specification
I.441 - ISDN User-Network Interface - Layer 2 Specification (Q.921)
I.451 - ISDN User-Network Interface - Layer 3 Specification (Q.931)
I.460-I.464 - Multiplexing, Rate Adaption and Support of Existing Interfaces

TABLE 5

Beside SG XV, a large amount of the work of SG VII, SG XI, and other SG's in addition to SG XVIII support ISDN. Table 6 lists, for example, Recommendations produced by SG VII relating to ISDN, (including key Recommendations for Packet and other services besides ISDN). In a similar fashion SG XI, has produced a number of Q Series Recommendations for ISDN, which are likely to have been put into the I Series by the Plenary Assembly. (Table 5).

Several ISDN - related questions were assigned to Study Groups VII, XI and XVII as well as to SG XVIII, with instructions for coordination on points of common interest. Study Group VII has prepared Recommendations X.30 (I.461) and X.31 (I.462) specifying support of X.21, X.21 bis and packet mode DTE's on an ISDN. Recommendation X.1 has been modified and new X.10 drafted to include classes and categories of access for DTE's to data transmission provided by ISDN's as well as public data networks.

4. ACTIVITY IN ISO/TC97

TC97 is the principal entity in ISO dealing with ISDN matters. While TC97 has undergone some restructuring to improve its internal working and external liaison, no project has been lost in the shuffle. The Sub Committees most heavily involved are SC6 (Telecommunications and Information Exchange Between Systems, TIES), SC18 (Text and Office Systems, TOS), and SC21 (Information Retrieval Transfer & Management for Open Systems Interconnection, IRTM). The OSI Reference Model provides a means to group significantly different functions in an orderly way, improving peer level and peer function communications, and permitting alternative technologies to be substituted at given layers. The ISO model DIS 7498 is kept aligned with CCITT Rec. X.200. This work, among other tasks is assigned to SC21 by TC97.

Similarly, SC18 of TC97 has initiated development of a set of message handling standards, and has worked from the end user requirements point of view with SG VII in the X.400 Series of Recommendations.

These efforts will provide the "customers" for ISDN users and the traffic they will generate. At Level 1 and 2 of the Reference Model, we have work going on in TC97/SC6 dealing with several forms of Local Area Networks. These are based on development of Institute of Electronic and Electrical Engineers, and will be used in private networks, and also in internetting with PSTN, Public Data Networks, and the ISDN facilities. DIS 8802, which describes these LAN's, will be published in multi-fasicle form, and will be totally aligned with the IEEE Standard 802 family.

As with SG VII and other Study Groups of CCITT, the SC's of TC97 have completed work, mostly of general application, but some pointed toward the ISDN. A new modular connector (8 pin) is under study in CCITT (SG VII, XVIII), 97/6/WG3 for user needs and function, and IEC/TC48B for electrical and mechanical parameters. It will be an important part of the compact portable work station that will be used in great quantities in Information Systems of the future.

As noted in the Bibliography below, ISO continues to generate and process Standards for the user of telecommunications facilities, and for the manufacturers of subscriber premises equipment for telematic services as well as private networks. Present DIS actions deal with CCITT aligned texts and more pioneering LAN and "Connectionless" configurations.

5. ACTIVITY IN IEC

While not too much has been achieved during their short existence, IEC/TC83 is addressing the use of Fibre Optic elements and links (this is also of interest to SG XV. Most importantly, the Home Electronic System is just starting up here. It will consider the low-cost needs of home owners and consumers,

STUDY GROUP VII RECOMMENDATIONS 1981 - 1984

X.1	International User Classes of Service in Public Data Networks and Integrated Services Digital Networks (ISDN)
X.4	General Structure of Signals of International Alphabet No. 5 Code for Data Transmission over Public Data Networks
X.10	Categories to Access for Data Terminal Equipment (DTE) to Public Data Transmission Services provided by PDNs and ISDNs through Terminal Adaptors
X.25	Interface between Data Equipment (DTE) and Data Circuit Terminating Equipment (DCE) for Terminals operating in the packet mode on Public Data Networks
X.30 (I.471)	Support of X.21 and X.21bis based DTE's on the ISDN
X.31 (I.472)	Support of Packet Mode Terminal Equipments on an ISDN
X.32	X.25 Terminals accessing a packet switched PDN through a PSN
X.50	Fundamental Parameters of a Multiplexing Scheme for the International Interface between synchronous Data Networks
X.50bis	X.50, with a 48-Kbit/s User Signalling Rate Transmission Scheme
X.51	Fundamental Parameters of a Multiplexing Scheme for the International Interface between synchronous Data Networks using 10-bit Envelope Structure
X.51bis	X.51, with a 48-kbit/s User Signalling Rate Transmission Scheme
International Multiplex Links at 64 kbit/s	
X.53	Numbering of Channels
X.54	Allocation of Channels
Interface between synchronous Data Networks:	
X.55	Using 6+2 Envelope Structure and SCPC Satellite Channels
X.56	Using a 8+2 Envelope Structure and SCPC Satellite Channels
X.96	Int'l Routing Plan for PDN
X.121	Int'l Numbering Plan for PDN
X.141	General Principles for the Detection and Correction of Error in Public Data Networks
X.150	Principles of Maintenance Testing for Public Data Networks using DTE and DCE Test Loops
X.180	Administrative Arrangements for International Closed User Groups (CUGs)
X.200	Reference Model of Open Systems Interconnection for CCITT Applications
Message Handling Systems:	
X.400	System Model - Service Elements
X.401	Basic Service Elements and Optional User Facilities
X.408	Encoded Info Type Conversion Rules
X.409	Presentation Transfer Syntax and Notation
X.410	Remote Operations and Reliable Transfer Server
X.411	Message Transfer Layer
X.420	Interpersonal Messaging User Layer
X.430	Access Protocol for Teletex Terminals

TABLE 6

but it may also try to serve some small business needs.

6. OTHER TELECOMMUNICATIONS STANDARDIZATION ACTIVITIES

ISDN will benefit by the work going on in European Computer Manufacturers Association, Federal Information Processing Systems, and IEEE (referred to above). These three bodies each have unique modi operandi, which sometimes are most efficient in expediting a particular standard approval. All have liaison with the ISO, IEC, and CCITT, noted in earlier sections. While the standards writing bodies introduced in this section is not exhaustive, it covers the last important group we would look to for ISDN standards. They are well directed manufacturer, user, and academic interests to focus on the standardization issues.

7. BENEFITS FROM THE VIEWPOINT OF THE USER

Both my presentation last year and the descriptive remarks above have mentioned some of the capabilities in a DTE that can be available for the first time or can be more effectively accomplished when used in conjunction with the ISDN. The value of these features and services to the user will be the subject of this section. Early videotext implementations have chosen fairly simple types of character and symbol presentation: the use of the mosiac of six-pixel elements gives great flexibility in what can be composed, but it is cost effective in an environment of limited bandwidth of low refresh rate, or a limited resolution, or combination thereof. Systems such as the North American NAPLPS and the Japanese Captain system, incorporated in T.101, provide higher resolution, more complex screen presentations. On one hand the Japanese need higher resolution because of the kanji character complexities and the Captain system certainly is very effective in this regard. Secondly, there is need to deal with graphic manipulation and for split screen presentations for some applications. These are achieved, again by higher resolution. And higher resolution comes with the greater bandwidth -- bit rate -- available in ISDN links and switches. For the screen-based high resolution terminal, unavailable on many prior networks, this advantage does not completely replace the need for hard copy. Many applications require certain statements of results to be done in hard copy for archival purposes. Some archives of course can be done by magnetic recording of one kind or another but for the purpose of human readability on demand, the more or less conventional hard copy still is the norm.

Digital Voice is a distinct capability on the digital ISDN facilities, since the ability to digitize speech signals, is in the realm of a few dollars via a chip which can be built into a conventional handset (if you wish that kind of terminal). Financial input or financial transaction terminals, which might be principally voice, or access to a financial network from a voice subscribers set, or possible (with or without voice recognition) at the called party's end. Subscriber sets at an incremental implementation cost of $10 to $20 can add a single line display for the editing before transmission or for ID verification before actual calling. For an additional $5 increment provides digitalization of the voice and so voice integration with digital networks at the same terminal is a convenient way for many low traffic applications to enhance voice and voice/data services.

Finally, the unique feature of security identification is enhanced on economic basis by the easy increment of encryption to the digital subscriber set just described. The features of authentication and encryption provide the ability to encode traffic so that the recipient and sender know that they and they alone are in communications and, in the encryption case, the content is not revealed to anyone else. It is beyond the scope of this paper to deal with the means of application of encryption and authentication or the problems and solutions dealing with these applications in concentrated networks. Nevertheless, we must cite this as a capability much more easily achieved in an ISDN than prior networks. Last, but not least, I would like to mention the services for teleconferencing. These can be achieved today by utilizing the public switched telephone network. So, while ISDN is not a necessity for this particular service, the refresh rate of display of factual data, charts, graphs, tables, etc. and simultaneously viewing speakers and presentors is more easily achieved with the bandwidths capable in ISDN, than via the public switched telephone network. Teleconferencing using conventional subscriber/"studio" equipment for (say) PSTN will perform each and every teleconference function, but will be slow -- longer conference time -- and use more telecommunications facilities -- more expense.

The user's requirements in high resolution, high refresh rate screen presentations; multiplexed work stations on one telecommunications line; combination of data and voice; and security can be satisfied better by ISDN facilities than by most currently available facilities.

8. VALUE FROM THE VIEWPOINT OF THE TRANSPORT CARRIER

In the ISDN, all transmission is in digital form. Techniques for digitizing voice have advanced to the point where commercially available chips exist in mass production to permit normal subscriber sets receiving your voice in analog form to produce a digital signal and a bandwidth corresponding to signaling rates of 32 kilobits per second at high quality and some marginal quality at half that speed. Of course, superior qualities would exist at higher speeds. Nevertheless, the 32 kilobit chip is a reality and is economic. Two "half duplex" circuits can therefore be multiplexed onto one 64 kilobit channel, or one "full duplex" digitized voice circuit can be handled on this 64 kilobit channel. ISDN designs and standards today offer access at 32 kilobits and 64 kilobits. Likewise, digital video has received a great deal of attention and the ability to compose a frame of picture presentation is readily apparent. Depending on the rapidity of action or screen refresh rate (frames per second or pixels changed per second), the bandwidth might be the conventional 6 MBS, or some fraction thereof. With these two techniques, digital voice and digital video, the majority of the activity of providing a virtually complete range of services in digital form is possible. With this much assurance of market it becomes economic therefore to provide wideband facilities for transmission of data and to utilize those bandwidths in a direct digital form.

The bandwidths that are most concerned would be the rates that have been in practice for a number of years for multiplexing purposes, the 1.544 megabit per second T1 carrier rates in North America and the 2.048 megabit per second rates in the European community. It is easy to see that these two frequencies are incompatible with each other. But sufficient practice has developed so that conversion devices are available at central offices and at gateways to provide a means of interconnection and synchronization of these networks. In regions of high traffic density each of those frequencies is multiplexed toward higher frequencies for microwave and satellite transmissions and one can easily calculate the lowest common multiplier to find a multiplexing frequency common to both, if you wish. The multiplexing equipments are not new with ISDN; their demand rises because of ISDN. The ISDN provides base capabilities for interconnection at the 64 kilobit rate and at the 32 kilobit rate.

User communities are desiring direct access to the higher rates 1.544 and 2.048 directly. The progress toward recommendations for such connnections have lagged, however, and are not approved at the end of the recently completed Study Period. It is not much in the interest of the carriers who wish to provide end to end services, integrated or otherwise. To provide such a high-speed connection, because their facilities would cater to the lower rates to a higher degree: in a service-oriented community of users the network that would essentially be private using higher performance individual terminals.

These digital signalling rates form the basis for multiplexing many channels. Table 4 indicates bandwidths up to 137 Mbps are being studied. The plans for multiplexing have side benefits in efficiently using satellite and microwave facilities, for mixing a variety of kinds of service, and expediting internetworking (especially when one network is based on 1544 kbps and the other 2048).

Carriers as well as users fully anticipate that there will be internetworking connections and technical problems associated with such connection are being faced. They raise questions, however, in the minds of people who have been used to providing on a monopoly basis end to end service, even when such service crosses international boundaries. One of the basic problems concerns the allocation of charges. How much is appropriate to the country in which the call is originated, how much to the transit countries, how much for the called country. these considerations almost immediately raise a second concern, namely that of incompleted calls. How should charges be assessed when a call has progressed, for instance, from one country through two transit countries, only to find the terminal at the other end out of service? I don't wish to try to give answers to these questions because much of the specific rate-making will be a matter of agreements between the countries involved. The work in Study Group III and, to some extent, Study Group I, the principles for making these rates, namely assessing what cost have been incurred, what facilities have been committed, preventing other revenue from being earned. Definition of services will help in rate principle studies. These problems have in deliberation for many years. I worked in Study Group III as far back as 1978 when these questions had already been introduced and some progress has been made over the intervening six years, but we are still far from broad consensus. In this regard, we must broaden our viewpoint when we consider multinetworking. Bi-lateral agreements may no longer be adequate for describing the pattern of rate structures. It may be necessary to consider a total region or perhaps worldwide tariff structure, from which multi-lateral agreements may be mandatory.

The problem and opportunity of universal addressing must be mentioned. There are two principle addressing approaches that have achieved certain popularity and practicality. One uses a field, the number of digits in the address, large enough so that every person or every device could have its own address and could connect to any network anywhere using that address. Since the traffic amongst all possible subscribers is not of uniform density, this scheme has certain natural inefficiencies. Another involves limiting the universality to a certain finite network community and then having a supplementary prefix addressing which would be used to take you from one network to another. This is the scheme in general use today (e.g. within your own area code, you do not "dial" the three area code digits). Its disadvantage is at the infrequent global addressing portion, it is not easily remembered. Subscribers frequently experience expensive wrong numbers.

The carrier is concerned about futile call attempts and concerned about overhead; i.e. how much time is taken in dialing extensive sequences of digits. The carrier and the processor are both concerned about the standardization of billing forms. Obviously the successful completion of such a standard bill will be dependent on the address form adopted and also the resolution of the questions of tariffing and completed calls. There is a vast area of rate making when we look on a widely diverse community of international calls that will come about with ISDN.

It is also important that we deal with the matter of portability from the carrier's point of view. When the carrier provides end to end service he may like to restrict the portability of the connecting point of the terminal operators. I would think that it would be foolish if he were to attempt to prevent any portability, although I suspect the administrations who are not used to private networks and the large activity of Local Area Networks, may not be ready to deal with the portability question with respect to addressing and billing.

In those entities where ownership of the DTE by the user is common it is evident that there should be much less difficulty in dealing with portability questions. Interconnection apparatus, housewiring, safety matters relating to such connections would become the dominant features of their concerns and probably would receive more attention in these communities than they would in the low portability domains.

9. ADVANTAGES TO THE INFORMATION PROCESSOR

We look in the section just concluded at the advantages to the transporter and the carrier. These are mostly administrations, but I did not want to restrict our thoughts to administrations only. Before that, we talked about the user, primarily the individual user rather than a large commercial user, where traffic for his business includes substantial information processing of the traffic he receives and is responsible for sending the results. ISDN is an obvious benefit to the bulk user since his basic internal traffic is normally, and always really has been, in a digital form. Coding schemes for security, from an information theory point of view, have many beneficial characteristics that serve to balance energy levels for quality of transmission and inter channel interference reduction. Check sums of one kind or another, are beneficial both for numerical calculations and for insurance of correct connections, choices of frequencies etc. Modulation techniques when started from digital forms and with proper addressing can cope with various redundancy and can cope with multiple transmissions at different parts of the message structure and for error correction techniques, as well as multiplexing of signal groupings of a wide range of average data rate and instantaneous peak data rate considerations. ISDN can offer a probable improvement in utilization of bandwidth of about 30% although exact improvement cannot be stated until you know the mix of the traffic. Experience in effecting these changes has been growing over the past decade or two, through the use of packet services and other digital multiplexing schemes used in computer front ends.

In the two prior sections we did not talk about message formats since we were dealing with diverse services where message formats are by nature somewhat unique: voice, video, facsimile and data. In the area of information processing, however, regardless of the data rates involved, standardization of message formats is an important consideration. Standardization in this direction has made considerable progress under Study Group VII in the previous Study Period. There are many good Recommendations have been achieved in that particular activity. These Recommendations are important to the information processor because of his relationship to the information provider.

The information provider may be a separate organization from the processor or the same. He may, in either case, be at some distance or may be adjacent with obvious differences in the communications needs. When the communication needs have been established, however, it is desirable that one or more processors can connect to one provider or vice versa. The same thing is true with regard to a standard scheme for addressing. The information processor is probably better able to cope with the universal address, but probably would be more convenient to deal with the dual or triple hierarchy address structure.

Another important consideration for the information processor is availability of open system connectability. When subscribers have conformed to OSI interfaces and protocols they can be added or subtracted to a network or processing service regardless of their specific prior preparation. As long as the capabilities for network control, for message structure, etc. follow a standard system, I doubt if we could find any information processor objecting to the open systems capability, whether the processor utilized the current large inventory of hugh mainframes, whether he had a local network connected to a high number of mini or personal computers to form his processing element.

10. OPPORTUNITIES FOR THE INFORMATION PROVIDER

At this stage of large information system and service development, most information providers would have catered to one service where he has a data bank in high degree of completion. He is likely to wish to expand his operation by finding more subscribers who would need to access that data base or to add to it. Once the provider has established a service and has expanded his apparatus, his interest usually goes to finding more diverse customers, and providing multiplicity of services. When he reaches that degree of sophistication, it becomes significant that he then have uniformity in practices and that he provide security between the several services. He then becomes a candidate for some degree of encryption and/or authentication. From the standpoint of addressing what we had said above concerning the processor, refers to the provider equally.

11. IMPACT ON THE SYSTEMS MANAGER

The last area that I would like to draw your attention to is the system manager. This section presents a few remarks that concern him. The system manager is responsible for integrating the many services that make up an information system: the providers, the processors, and the myriad of subscribers with "subscriber sets" (i.e. terminals with or without processing capability.) He must accumulate and provide in cooperation with the various administrations and RPOA's, the necessary communications facilities, and must deal with all the rates that are associated with the facilities and services he desires and to reallocate resources and charges to the several subscribers. We draw your attention in this regard to our remarks in the section on Carriers and their rate making problems. Much is similar in the area of the system manager for structuring data processing, storage and transportation charges. He may wish to pass certain charges on to the other subscribers or he may wish to absorb some of these, as his competition would urge him to do. So while he needs the information that we have talked about, the carrier having, the manager must also do studies to deal with his marketing needs as well as his operating profitability. The system manager faces the consideration (which is usually a problem for the various entities as well): namely, the matter of transport or data flow and the protection of privacy amongst the subscribers and amongst the national interests of the entities involved. The system manager in a responsible way will deal with the protection of such privacies, but he would like to have uniform guidelines that would provide a code of conduct for the ability of operating a multi-national information system. Artificially restraining the location of data banks and artificially taxing the motion of such traffic does not represent the principles of GATT nor the basic ideas of free international trade.

12. CONCLUSION

I have presented the state of progress in the development of standards needed for an ISDN for the subscribers who will use it. I have indicated that cooperation and forward-looking planning is needed so that both the transition and the ultimate operation of ISDN, based upon current technology can be achieved on a global basis. While a very rapid installation of equipment, and establishment of service could be an economic impact too severe to bear, many small entities of the Pacific Basin should give consideration in the beginning to a mixed system wherein local subscriber needs are piggy-backed on a larger international type information system, who would normally make the investment for large equipment of information processing, large volume transmission channels, and a maintenance facility for sophisticated DTE. This kind of a combination of activity represents an economic start over much of the Pacific Basin needs. As I stated last year, the use of satellite hops as well as some other sophisticated techniques may not be a luxury, it may indeed be a very convenient way to achieve some of the Pacific Basin early implementation of ISDN's.

13. REFERENCES

- The CCITT "Yellow" Book lists the question for the 1981-1984 Study Period. ISDN Recommendations appear in many of its Volumes/Fascicles.

- Documents submitted to CCITT/APVIII for approval and consideration are APVIII/1-144. They are circulated before the Plenary to only Administrations and accredited International Organizations participating in APVIII. Subsequent to the Plenary, those approved can be helpful until the "Red" Book is available.

- ISO/TC97N1403, organization of TC97.

- ISO/TC97N1323, the latest annual report of the TC97 Secretariat.

- ISO, IEC and ECMA Mementos.

- Proceedings of PTC 81-84.

14. ACKNOWLEDGMENTS

This paper had to be written in the midst of final writing, future planning, and self appraisal of the major Standards Writing Bodies responsible for the ISDN Standards and Recommendations. To assemble the data, and add insight of what approvals would occur in the fall of 1984, I have leaned upon key SG Chairmen, especially Vern MacDonald (SG VII) and Jack Ryan (SG XI); the Central Secretariat Staffs of CCITT, ISO, and IEC and ECMA and IEEE. Finally, I have consulted various experts active in many of the writing committees I have mentioned. I am grateful for their information, judgement and critical review of the subject matter presented.

COST OF SATELLITE FACILITIES LEASING FROM INTELSAT VERSUS PURCHASE OF A DOMESTIC SATELLITE SYSTEM IN THE PACIFIC OCEAN REGION

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ABSTRACT

Because of the large distances involved and the ability of satellites in the geostationary orbit to provide both wide area and selected coverage, INTELSAT satellite communications systems must continue to provide the major proportion of international communications on a cost effective basis in the Pacific Ocean area.

Thus from the perspective of the user, INTELSAT has the advantage of already having a traffic and revenue basis justifying a global system including a Pacific area capability which can normally accommodate additional requirements.

This paper illustrates INTELSAT's ability to provide a cheaper and more flexible response to domestic requirements under most circumstances provided that cost effectiveness is the major criterion.

1. THE INTERNATIONAL SYSTEM (INTELSAT)

The International Telecommunications Satellite Organization "INTELSAT" serves the international community of nations comprising some 109 Signatories and through the Operating Agreement responds to the needs of the Signatories by providing public switched telephone circuits, wideband (TV and other) leases of various kinds and also the newly approved INTELSAT Business Services (IBS) and other relatively narrowband services.

Currently there are 15 satellites in orbit but this number could increase to meet demand and might vary for periods depending on launch success rates and other factors.

There are at present two Pacific Ocean Region satellites and it is planned that this will become two protected working satellites plus one flying spare for a total of three in 1987. There are also three satellites in the Indian Ocean Region which includes South East Asia also Japan and Australia.

The INTELSAT plans call for a number of launches and various movements of satellites worldwide to sustain the three satellites in the Pacific and three in the Indian Ocean. If any launch failures occur, extra launches will be planned to sustain the three satellite deployment plans.

This large number of satellites provides an ability to serve most needs at short notice. Once in orbit, satellite failures are very rare, in fact most INTELSAT satellites last well beyond their predicted lifetime.

The INTELSAT system is supported by 550 INTELSAT staff and is guided by the countries of the world to ensure that the system is managed for the benefit of the owners who are also the users in a very professional way both managerially and technically.

The point that is being made is that there is a large degree of stability in INTELSAT including a capital investment of over $2-billion and a published range of services and applicable tariffs which are amended as required to meet the needs of the users.

Appendix 1 which was prepared in respect of the Asia Pacific Broadcasting Union (ABU) is illustrative of the kind of support INTELSAT enjoys - in this case of member countries accessing INTELSAT satellites.

2. TRANSPONDERS AVAILABLE

There are currently transponders available for lease at 6/4 GHz in all Ocean areas including the Pacific, and starting in 1985 there will be 14/11 GHz capacity in the Pacific which will expand in 1987 coincidental with the commencement of three satellite operation.

Should large scale requirements arise, arrangements could probably be made to hasten the arrival of satellites with greater capacity in the Pacific.

However as examples:

a) The space segment cost for a 36 MHz lease which can accommodate one television channel in a so-called 'hemi-beam' which could handle a domestic requirement would be US$1.6M per annum - based on a 5 year lease - for a fully protected service.

b) The space segment cost for a preemptible service for the same 36 MHz lease accommodating one TV channel would be US$0.8M per annum - based on a 5-year lease.

Once again we should stress that while it must be clearly stated that the spare satellite is in place primarily to serve as a replacement for the one or two satellites carrying public service telephony, nevertheless the risk of the spare being preempted is low and many users find the 50% price reduction very attractive.

3. USER FLEXIBILITY

But the main point of this paper is not the cost for the service but the flexibility which the user has in operational and economical terms.

- Small reservation fee.
- Ability to cancel on payment of 10% of the remaining contract value after 2 years.
- Ability to upgrade lease from preemptible to non-preemptible.
- Ability to order up transponders one at a time.
- Knowledge that the system is supported by an international organization in which the concerned country or administration either has a voice or can arrange to have a voice.

In summary, a flexibility to tailor the costs to the actual demands which are often difficult to predict 5 or 10 years in advance.

4. PURCHASE OF A SATELLITE FOR DOMESTIC SYSTEMS

Before describing in detail the advantages of the leasing of a transponder or even a half transponder from INTELSAT, it might be best to spend a moment describing not only the costs but also the hidden costs and risks involved in launching a satellite for domestic requirements.

Satellite system costs depend on the system design criteria and in a small single working satellite system it must be stressed that the design and operational configurations chosen are driven by the most exacting criteria.

For example, if a given country wished to carry both domestic public service telephony and occasional use TV, it is necessary to have a configuration which includes an in-orbit spare due to the need to have uninterrupted public service telephony. However, for occasional TV use service a configuration with a ground spare would have been perhaps quite adequate, with a consequential saving in launch costs.

Whereas, if the same country were to use INTELSAT, the type of leases offered can be customized to the particular needs of each type of service. For instance, for telephony service a non-preemptible lease can be considered, while for occasional TV a preemptible lease might be adequate. INTELSAT can provide this kind of flexibility that translates into savings to the user.

3. Ability to Cancel

A similar type of flexibility is the ability to cancel on payment of 10% of the cancelled portion of the contract after 2 years. The value of this flexibility is enhanced by the ability to upgrade (see next paragraph).

4. Ability to Upgrade

Again taking the same example, if the two preemptible transponder leases were required to be upgraded to non-preemptible due to changing circumstances or for that matter a very deliberate plan, then there would be no cancellation charge.

This it is contended is a major advantage of leasing from INTELSAT.

5. Ability to obtain additional capacity as needed

The aspect of fill factor, if of critical importance when considering a complete satellite system as a cost per active transponder, quickly increases if all transponders are not full and this must be the case most of the time.

To take a very simple example, if a satellite is only half full then the cost per working transponder doubles.

More typically, a well designed facility could fill to 25-30% very rapidly and might be, say, 85% full after 4 years, and given a 7 year life the cost per working transponder is more than 50% greater than the nominal transponder cost.

Needs almost always increase with time no matter what service categories are considered.

However when leasing from INTELSAT, additional capacity of the category of service can be ordered and then paid for as requested.

6. Ability to achieve the right scale

With INTELSAT, the ability to "scale" space segment capacity to specific requirements is very broad. Transponder leases as small as one-quarter of a transponder (36 MHz in the C-band) or one-eighth of a transponder (72 MHz in the Ku-band) are available. If even these capacities are too large then the VISTA service for domestic or regional services is available on a channel by channel basis with INTELSAT requirements being very low for subscribers.

8. CONCLUSIONS

This paper has attempted to make two main points.

Firstly, the costs of deploying a reliable satellite system go far beyond the cost of a single satellite. An in-orbit spare or at least insurance cost are necessary. Plus the money must be expended early and this is likely to raise the cost calculated against the first day of operation by a figure in the range of 30% to 40% depending on the situation.

Secondly however, the even more important point is that any satellite design is constraining and once decided upon does not allow a flexibility to accommodate new considerations which might reasonably call for a modification or delay.

On the other hand, INTELSAT is a reliable supplier with a large number of satellites already in orbit and can therefore offer a good deal of flexibility at reasonable cost.

A satellite program takes some 4-5 years to put into effect and then the satellite lifetime is 7-10 years - it is almost inevitable that changes must occur during this time period and it is thus suggested that INTELSAT is likely to be able to provide the best cost effective solution for domestic needs.

5. SATELLITE SYSTEM COSTS

Typical system costs for a domestic system based on a satellite of the PAM-D class (approximately 1150 Kg in transfer orbit) would be:

	1985 US Dollars
Non recurring costs	$ 30M
Operational Satellite	$ 45M
In-orbit Spare	$ 45M
Two launches (either Driane or Shuttle plus upper stage)	$ 60M
Program costs (systems planning, monitoring of fabrication, etc.)	$ 12M
Subtotal	$192M
Insurance (15%)	$ 29M
2 TT&C Stations	$ 12M
Total	$233M

Not only must the major portion of this cost be paid before any revenue is received but progress payments are actually escalated due to inflation. The combination of inflation and interest during construction can easily raise the 1985 cost by approximately 40% (assuming a three and a half year construction program, 8% p.a. for inflation and 14% p.a. for interest during construction). Therefore, by the time the first spacecraft is in orbit ready for service, the actual cost of the program is some $325M.

This manner of calculating system costs is normal from a financial "present value" perspective. It is also the correct way to compare with the INTELSAT alternative where the money is paid when the service is received and not years in advance.

6. SUPPORT COSTS

The above assumes launch support costs such as tracking stations are included.

However, to design, operate and maintain the satellite system, if the sponsor country does plan to take an active role, typically involves gradually establishing a supporting staff of over 200 people many of them engineers and managers with very special skills, almost regardless of the system size. In many countries the availability of such skilled staff would be a factor to be verified.

7. THE FLEXIBILITY AND COSTS OFFERED BY INTELSAT

If we return now to the advantages of INTELSAT, the first and foremost is flexibility - coupled with modest cost tied to actual use of space facilities.

1. Transponder lease periods of 2, 5 or 7 years are offered.
2. Small reservation fee.

Starting 1 January 1985 the reservation fee for a lease will be a one time charge of 10% of the annual lease charge for the facility being reserved to a top limit of $100,000. The reservation fee is then applied against the lease charge, i.e. the lessee pays the other 90% when using the facility. In the example of a non-preemptible lease, the reservation fee would be a one time charge of $100,000.

Firstly, a reservation fee is probably only necessary when a virtual guarantee of availability is required.

Secondly, the main argument is that to take an extreme case, a reservation fee of $100,000 is a very small sum to lose if plans do change as against losses in cancelling or significantly changing a project which had been budgeted in the region of $200-$300M. The actual losses would obviously vary greatly depending on the status of the project particularly the costs committed and incurred.

In many cases, requirements are so changeable and dynamic at this time that this aspect of flexibility cannot be overstressed.

APPENDIX 1

USE OF INTELSAT BY MEMBER COUNTRIES OF THE ASIA PACIFIC BROADCASTING UNION

(October 1984)

	International Earth Stations			
Country	Std.A	Std.B	Std.Z	Domestic Lease
Afghanistan				
Australia	4	2	77	Yes
Bangladesh	1	1		
China, P.R. of	4			Planned
Egypt	1			
Fiji	1			
Hong Kong	3			
India	2		36	Yes
Indonesia	2			
Iran	1			Planned
Iraq	1			
Japan	4			
Jordan	1			
Korea, Rep. of	2	1		Planned
Laos				
Malaysia	2		2	Yes
Macau		1		
Nepal		1		
New Zealand	1			Planned
Pakistan	1	1		Planned
Papua New Guinea		(1984)		
Philippines	2	1		
Qatar	1			
Saudi Arabia	1		13	Yes
Singapore	1			
Solomon Islands		1		Planned
Sri Lanka	1			
Thailand	2		16	Yes
Turkey				
Vietnam, P.R. of				
Western Samoa		1		

SUMMARY TOTALS

Number of Earth Stations Operating in IOR or POR

Standard A	38
Standard B	10
Standard Z	144

DOMESTIC LEASES

Countries with operational leases	5
Countries with planned leases	6

A.B.U. MEMBER COUNTRIES ACCESSING INTELSAT SATELLITES

Indian Ocean Region				Pacific Ocean Region	
Primary (60°E)		Major Path (63°E)	Spare (57°E)	Primary (174°E)	Spare (179°E)
Australia *	Macao	Australia *	India	Australia *	Australia
Bangladesh	Malaysia *	China (P. Rep.) *	Thailand	China (P. Rep.) *	Japan
China (P. Rep.)	Nepal	Hong Kong *	Malaysia	Fiji	Korea (Rep.)
Egypt	Pakistan	India *		Hong Kong *	Philippines
Hong Kong *	Philippines *	Iran		Indonesia *	
India	Qatar	Japan *		Japan *	
Indonesia *	Saudi Arabia	Singapore		Korea (Rep.)	
Iraq	Singapore			Malaysia *	
Japan *	Sri Lanka			New Zealand	
Jordan	Thailand *			Philippines *	
Korea (Rep.) *				Solomon Island	
				Thailand *	
				Western Samoa	

* International Earth Stations in both IOR and POR

THE AUSTRALIAN SATELLITE SYSTEM - PRESENT & FUTURE PLANS

by

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ABSTRACT

This paper provides an overview of Australia's national satellite program - AUSSAT - with a brief description of the system, its intended applications, and future plans for the next generation.

INTRODUCTION

Australia is now in the final six months leading to the launch of its first national communications satellite - an event that will herald the beginning of a new era in Australia's communications history. When commercial operations through this first satellite commence in October of this year, the whole of the country will be covered for the first time by a comprehensive telecommunications system that will enhance and diversify the existing terrestrial network and bring the benefits and innovations of modern space-based communications technology to every corner of the country.

AUSTRALIA'S SATELLITE OPERATING COMPANY

Australia's national satellite system is owned, operated and managed by AUSSAT Pty Ltd, a commercial company set up by the Australian Government in 1981. Current ownership of the company comprises a 75 percent shareholding by the Australian Government and 25 per cent by Telecom Australia, the national terrestrial telecommunications carrier.

AUSSAT presently employs around 160 staff, the majority of whom are engineers and technicians with extensive experience in the satellite communications field. A number of key technical and management staff have been involved in the AUSSAT program since its inception some five years ago, having followed the program through the early system design and development phase to its present stage where construction of major elements of the system is now reaching finality.

By July, the company expects to expand to a staff of 200, with some 50 people - engineers, scientists, technicians and managers - involved directly in the Company's space engineering activities. Many of these staff have now returned to Australia after being based at the Hughes spacecraft construction plant in Los Angeles during a major portion of the spacecraft design and manufacturing phase. What these staff bring back with them to Australia is the management and technical expertise to support AUSSAT's future space-related planning and operational activities - skills that will be important as we embark on the start of commercial operations on the first generation of satellites and commence the planning activities for a follow-on system.

THE AUSSAT SYSTEM

The AUSSAT system (refer Figure 1) will comprise three identical Ku-Band communications satellites and a wide range of communications earth stations. The first satellite (refer Table 1) will be launched aboard the NASA Space Shuttle Challenger in August, the second (also by Shuttle) in November, and the third, originally planned as an on-ground spare, will be launched next year on the Ariane launcher, two years ahead of the originally projected launch date to cater for a high demand for satellite services throughout Australia. The satellites will serve Australia from geostationary orbits at 156, 160 and 164 degrees East.

Table 1

Planned Program Schedule

Satellite	Launch Date	Ready for Service
1st Generation		
AUSSAT - 1	8/85	10/85
AUSSAT - 2	11/85	1/86
AUSSAT - 3	6/86	8/86
2nd Generation	(preliminary)	
AUSSAT - 4	1990-91	1990-91
AUSSAT - 5	1992	1992
AUSSAT - 6	1992-93	1992-93

AUSSAT's three communications satellites are being constructed by Hughes Aircraft Company in California. These satellites are based on the Hughes-built HS376 spinner design, a product line utilizing mature flight-proven technology.There will be 21 such satellites launched by the time the first AUSSAT "bird" is placed into orbit. The satellites utilise hardware which is to a large extent identical to that on other HS376's. The key exceptions are the communications payload and antennas which are custom-tailored to Australia's unique coverage and service requirements (refer Figure 2).

The AUSSAT system utilises Ku-Band frequencies, with transmissions in the 14 - 14.5 GHz uplink frequency range and 12.25 - 12.75 GHz on the downlink (refer Figure 3). The communications payload on each AUSSAT satellite is the most advanced Ku-band system yet designed for any Hughes HS376 spacecraft, and has been especially tailored to meet the unique requirements of Australia's geographical service needs. Incorporated into the design are several unique features including 12 Watt and 30 Watt transponders, ten shaped antenna beams, and a substantial level of transmit beam switching.

The coverage patterns for the spacecraft antennas have been tailored to match closely the intended service requirements, with careful consideration of population distribution and users needs, both regionally and nationally. Each satellite has provision for two national receive and transmit beams, and four downlink spot beams covering Western Australia, Central Australia (Northern Territory and South Australia), North East Australia (Queensland) and South East Australia (New South Wales, Victoria and Tasmania). A fifth spot beam is also provided to cover Papua New Guinea.

The communications payload onboard each satellite will carry 15 transponders (refer Figure 4), of which 4 are high powered (30 watt channels) and 11 are standard powered (12 watt channels). Each transponder has the capability of receiving and transmitting one or more high quality colour television signals, up to 1,000 two-way voice circuits, or up to 64 megabits per second of data.

AUSSAT's major contractor, Hughes Aircraft Company, is supplying two Tracking, Telemetry, Command and Monitoring (TTC&M) stations, the primary station to be located in Sydney with a back-up station on the other side of the continent in Perth. The functions of these TTC&M stations are to provide mission phase and on-station satellite control with complete command, telemetry, ranging and orbital determination functions.

To provide access to the satellite system for customers not wishing to own and operate their own facilities, AUSSAT has installed eight large (13-18 metre) Major City Earth Stations (MCES) in the capital cities of each State and Territory. The MCES's in Sydney and Perth are co-located with the TTC&M facilities. Additionally, AUSSAT has purchased a range of small (2.1 - 3.7 metre) low-cost single voice channel Minor Earth Stations for demonstration purposes and use by low capacity users.

One of the significant features of AUSSAT's operation is that customers may own and operate their own earth station transmit and receive facilities. A wide range customer earth stations will be used to cover the diversity of service applications planned for the AUSSAT system - such as small 1.2 metre TVRO's for direct broadcast services, 2.5 - 6.5 metre voice/data earth stations for private business satellite networks, and 4.7-13 metre earth stations for television program interchange and relay applications.

To regulate and monitor satellite access with this diverse customer base, AUSSAT has developed standards which define the various technical and operating requirements for customer-operated earth stations. Additionally, a sophisticated computer-based communications monitoring system has been installed at the AUSSAT network operations centre and will be used to monitor the RF parameters of transmissions through the satellites.

SOME EXISTING SERVICE DEFICIENCIES

With a land area of almost eight million square kilometres and a distance of nearly 4,000 kilometres between East and West coasts, Australia is similar geographically to countries like the United States, Canada, Brazil and India where communications satellites have been used as an effective and economic means of serving remote and isolated regions. However, unlike these countries, Australia has a comparatively small population of only 15.4 million, most of whom live in the cities of the eastern seaboard and the state capitals situated around the coastline. The remainder of the population, a small percentage of the total, is thinly dispersed over the inland areas of the country, referred to as "outback" Australia.

While these "outback" areas contribute greatly to the nation's mineral and pastoral wealth, they suffer enormously from a lack of effective communications due to the substantial economic and technological barriers posed by distance, the environment and the low population. For example, it is estimated that up to 40,000

Australians in these areas rely on poor quality high frequency radio as the primary means of communicating with the outside world. Additionally, around 300,000 Australians in these outlying areas neither receive any form of broadcasting service now, nor can they expect to receive any by terrestrial means in the foreseeable future. Even within existing broadcast coverages around one million people receive only limited programming (generally one national program) or poor service quality.

SERVICE APPLICATIONS

Australia's first national satellite system will solve economically the communications problems of its remote areas and at the same time will provide satellite capacity which can be used to strengthen the existing terrestrial system as well as provide the opportunity to introduce many new telecommunications services.

Some of the immediate prospective benefits to flow from the AUSSAT system will include expanded television and radio broadcasting services, improved remote area telephone communications, enhanced distance education in outlying areas, new aeronautical communications services, voice and data communications for mining and oil exploration companies, emergency and disaster relief communications, and digital data services, facsimile, and video conferencing for a wide section of the Australian business community. Let me expand on some of these.

Broadcasting (refer to Figure 5)

The AUSSAT system will provide two broad classes of broadcast service. Firstly, a remote area direct broadcasting service called the Homestead and Community Broadcasting Satellite Service (HACBSS), using four 30 Watt spot beam transponders, will provide the means for extending radio and television services supplied by the Government-owned Australian Broadcasting Corporation (ABC) to isolated communities and dwellings throughout the vast outback regions of Australia. HACBSS programs will be received directly from the satellites, either into communities or by individuals, by way of a small receiving antenna of 1.2 - 1.8 metres in diameter. This service, will utilize a new advanced transmission system known as B-MAC (multiplexed analog component format). For commercial and other broadcasters however, the AUSSAT system will also provide the means for flexible and cost-effective interchange and distribution of television and radio transmissions between major cities and to regional centres. It is envisaged that some 60 per cent of the initial traffic loading on the satellites will comprise broadcasting services of the nature described above.

Remote Area Telephony (refer to Figure 6)

Telecom Australia will utilise the satellite system to provide telephony to remote and isolated communities. A total of 65 earth stations have been purchased which includes 60 remote telephony stations plus 5 special purpose transportable stations for itinerant use. An important feature of the satellite system for Telecom Australia will be flexibility which it provides in the choice of telecommunications technologies, both terrestrial and satellite-based.

Department of Aviation (DOA) (refer to Figure 7)

DOA will use the AUSSAT system to establish reliable voice and data links between 46 major manned air traffic control and flight service centres throughout Australia. These links will be used for dissemination of flight service data and co-ordination of air traffic control for aircraft entering and leaving each manned centre's controlled airspace. The system will also be used to provide full VHF air-to-ground coverage on all domestic commercial flight routes above 6,000 metres. To establish its aeronautical satellite service, DOA is installing an identical pair of aeronautical earth stations at 101 separate locations, providing an Australian-wide aeronautical satellite communications network.

Business Voice/Data Networks (refer Figure 8)

One of the areas of significant growth potential for satellite services in Australia will be applications involving private business telecommunications networks, electronic funds transfer, video conferencing, and digital data transmission. In fact, following the initial period of total loading during which more than 60% of the system capacity is expected to comprise broadcast-related traffic, the demand for digital data and related services will likely constitute the major area of traffic growth on the AUSSAT system.

Other Uses

Additional to the above, the AUSSAT system has the provision for extending domestic telecommunications and broadcasting services to Papua New Guinea (PNG) should that Government elect to use the system to support the introduction of television or to strengthen its telecommunications system with satellite supplied services.

FUTURE PLANS

During the coming 2 year period, AUSSAT will be undertaking perhaps the most demanding implementation schedule of any satellite operator to date - with three satellite launches scheduled, the first of which is to occur in August, and the allocation of the bulk of available capacity on these satellites for commercial service.

Against this background, AUSSAT expects to be well down the track of contracting for a second generation of satellites in the 1987-1988 timeframe - just 2-3 years from now. The launch date for the first of these follow-on satellites is expected to occur in about 1990-91.

The design of this second generation of satellites will be central to the on-going development and expansion of the AUSSAT system. An area of continuing and fundamental importance will of course be the maintenance of continuity of services provided by AUSSAT's first generation satellites. The long-term nature of the communication networks of AUSSAT users will require careful planning to ensure a smooth transition between the first and second generation systems.

The second generation system will likely provide facilities and services for a wider range of special interest sections of Australian businesses, the community generally, and the Government. Such special interest requirements could encompass for example meteorological applications, remote sensing, remote site data collection, safety and distress communications, and maritime satellite applications.

Expanding from just a domestic system however, it is likely that the second generation AUSSAT system will look further afield than our own shores and Papua New Guinea. In this regard, it is envisaged that neighbouring countries such as New Zealand and the South-West Pacific nations could well be potential users of AUSSAT's next generation of satellites. Indeed, significant interest by these countries in such a venture has already been generated.

The communications requirements of the South-West Pacific countries have many similarities to those of Australia where the population tends to be concentrated in small areas but separated by large distances. The experience which AUSSAT will have gained in planning and operating Australia's national satellite system will position it well for providing assistance in the planning and provisioning of a possible South-West Pacific regional satellite network for the 1990's and beyond.

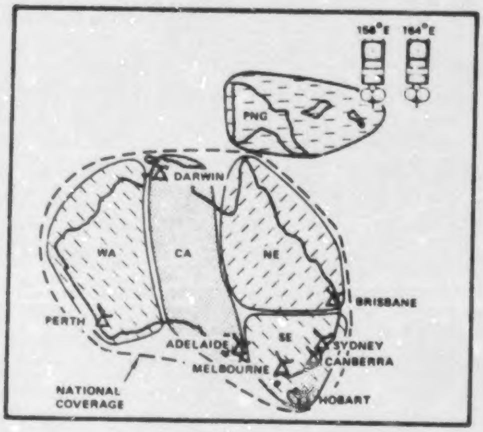
156°E
164°E
PNG
DARWIN
WA
CA
NE
BRISBANE
PERTH
ADELAIDE
SE
SYDNEY
CANBERRA
MELBOURNE
NATIONAL COVERAGE
HOBART

Figure 1. AUSSAT System Configuration Showing Major Earth Station Locations and Service Zones

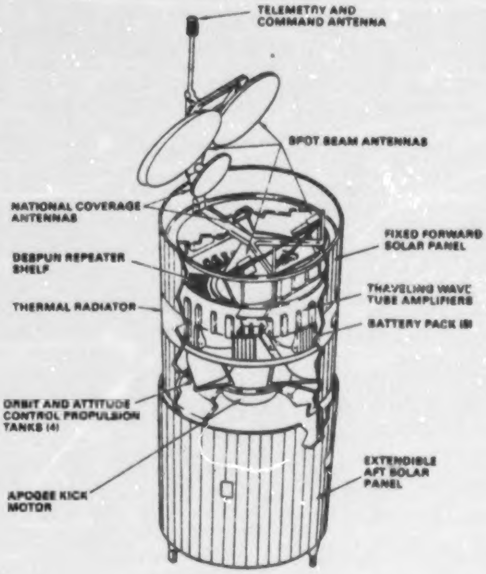
TELEMETRY AND COMMAND ANTENNA
SPOT BEAM ANTENNAS
NATIONAL COVERAGE ANTENNAS
FIXED FORWARD SOLAR PANEL
DESPUN REPEATER SHELF
TRAVELING WAVE TUBE AMPLIFIERS
THERMAL RADIATOR
BATTERY PACK (8)
ORBIT AND ATTITUDE CONTROL PROPULSION TANKS (4)
EXTENDIBLE AFT SOLAR PANEL
APOGEE KICK MOTOR

Figure 2. Breakaway View of the AUSSAT Communications Satellite

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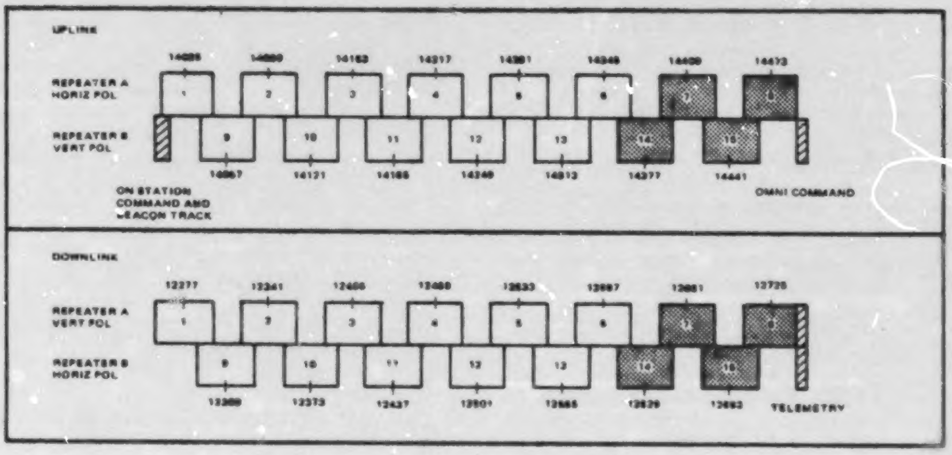
UPLINK
REPEATER A
HORIZ POL
REPEATER B
VERT POL
14025
14089
14153
14217
14281
14345
14409
14473
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
14057
14121
14185
14249
14313
14377
14441
ON STATION
COMMAND AND
BEACON TRACK
OMNI COMMAND
DOWNLINK
REPEATER A
VERT POL
REPEATER B
HORIZ POL
12277
12341
12405
12469
12533
12597
12661
12725
12309
12373
12437
12501
12565
12629
12693
TELEMETRY

Figure 3. Satellite Frequency/Polarization Plan

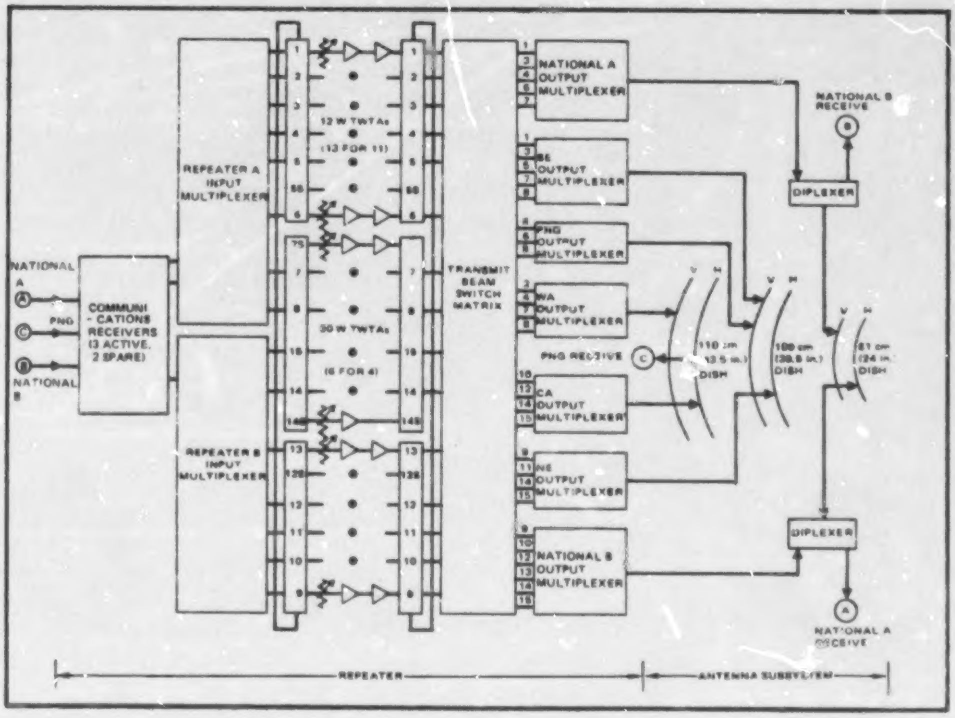
NATIONAL
A
PNG
NATIONAL
B
COMMUNI
- CATIONS
RECEIVERS
(3 ACTIVE,
2 SPARE)
REPEATER A
INPUT
MULTIPLEXER
REPEATER B
INPUT
MULTIPLEXER
12 W TWTAs
(13 FOR 11)
30 W TWTAs
(6 FOR 4)
TRANSMIT
BEAM
SWITCH
MATRIX
NATIONAL A
OUTPUT
MULTIPLEXER
SE
OUTPUT
MULTIPLEXER
PNG
OUTPUT
MULTIPLEXER
WA
OUTPUT
MULTIPLEXER
PNG RECEIVE
CA
OUTPUT
MULTIPLEXER
NE
OUTPUT
MULTIPLEXER
NATIONAL B
OUTPUT
MULTIPLEXER
NATIONAL B
RECEIVE
DIPLEXER
DIPLEXER
NATIONAL A
RECEIVE
V
H
110 cm
(43.5 in.)
DISH
100 cm
(39.8 in.)
DISH
61 cm
(24 in.)
DISH
REPEATER
ANTENNA SUBSYSTEM

Figure 4. Block Diagram of Communications Payload

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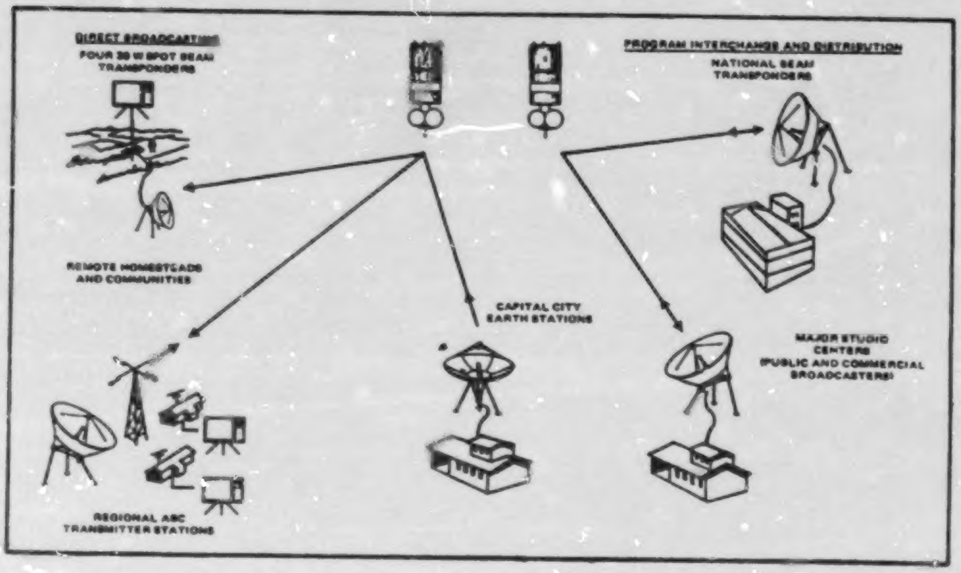
DIRECT BROADCASTING
FOUR 30 W SPOT BEAM TRANSPONDERS
REMOTE HOMESTEADS AND COMMUNITIES
REGIONAL ABC TRANSMITTER STATIONS
CAPITAL CITY EARTH STATIONS
PROGRAM INTERCHANGE AND DISTRIBUTION
NATIONAL BEAM TRANSPONDERS
MAJOR STUDIO CENTERS (PUBLIC AND COMMERCIAL BROADCASTERS)

Figure 5. Typical Television and Radio Services

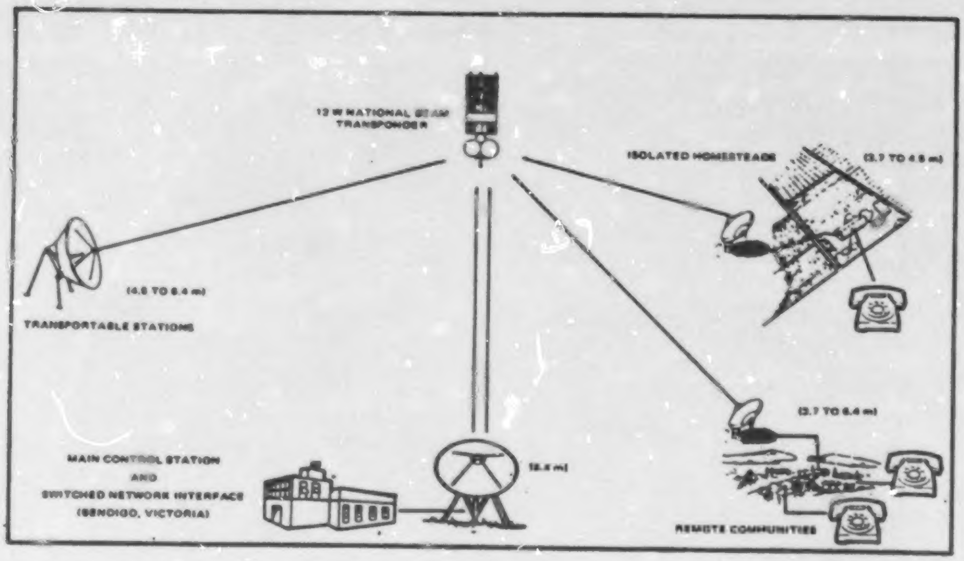
12 W NATIONAL BEAM TRANSPONDER
ISOLATED HOMESTEADS
(3.7 TO 4.5 m)
(4.5 TO 6.4 m)
TRANSPORTABLE STATIONS
(3.7 TO 6.4 m)
MAIN CONTROL STATION AND SWITCHED NETWORK INTERFACE (BENDIGO, VICTORIA)
(8.4 m)
REMOTE COMMUNITIES

Figure 6. Typical Remote Telephony Applications

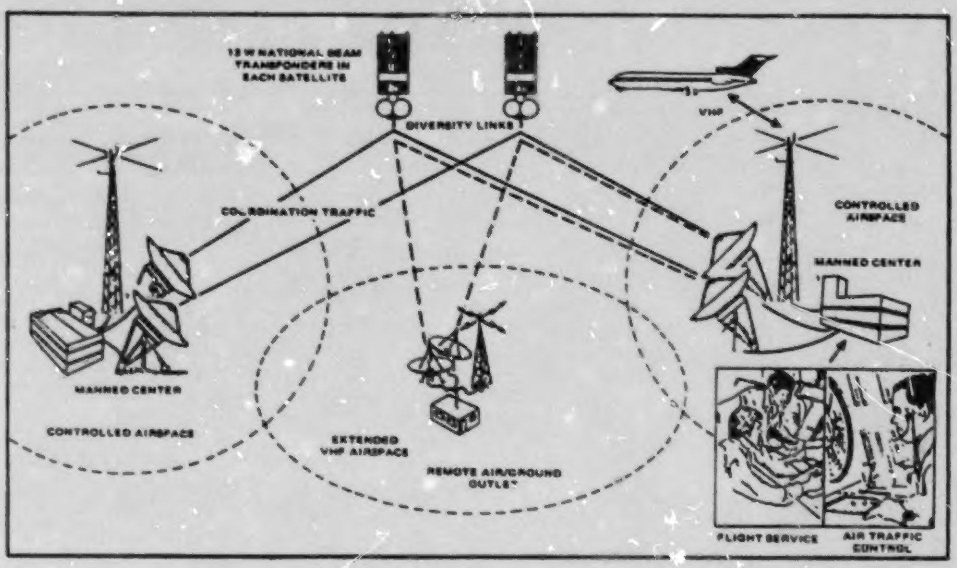
12 W NATIONAL BEAM TRANSPONDERS IN EACH SATELLITE
DIVERSITY LINKS
VHF
COORDINATION TRAFFIC
CONTROLLED AIRSPACE
MANNED CENTER
MANNED CENTER
CONTROLLED AIRSPACE
EXTENDED VHF AIRSPACE
REMOTE AIR/GROUND OUTLET
FLIGHT SERVICE
AIR TRAFFIC CONTROL

Figure 7. Aeronautical Satellite Services

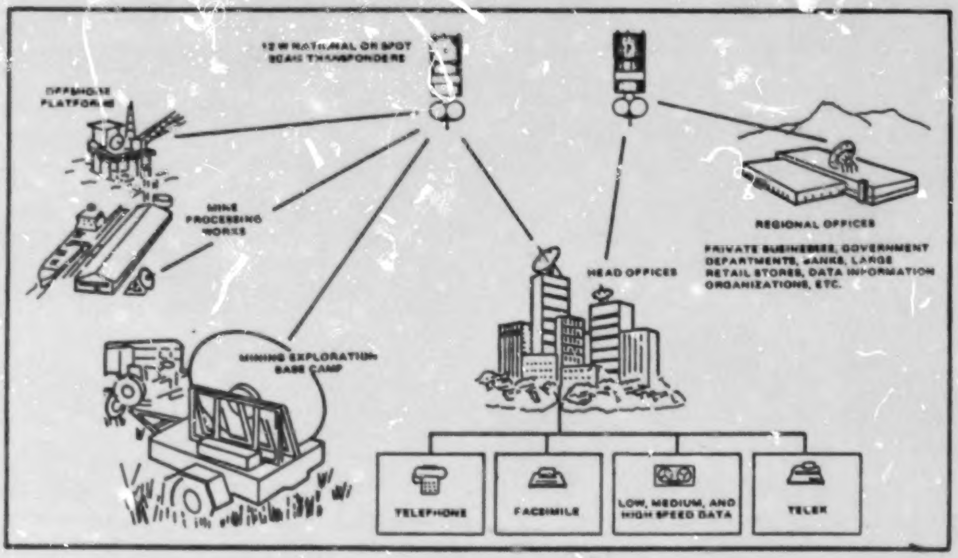
12 W NATIONAL OR SPOT BEAM TRANSPONDERS
OFFSHORE PLATFORMS
MINE PROCESSING WORKS
MINING EXPLORATION BASE CAMP
HEAD OFFICES
REGIONAL OFFICES
PRIVATE BUSINESSES, GOVERNMENT DEPARTMENTS, BANKS, LARGE RETAIL STORES, DATA INFORMATION ORGANIZATIONS, ETC.
TELEPHONE
FACSIMILE
LOW, MEDIUM, AND HIGH SPEED DATA
TELEX

Figure 8. Typical Minor Earth Station Useage

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"SYSTEM AND HARDWARE OPTIONS FOR DIGITAL TELECOMMUNICATION NETWORKS IN THE SOUTH PACIFIC"

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M.I.E. (Aust), Programme Controller
South Pacific Telecommunications Development Programme

1. Abstract

With the establishment of the South Pacific Telecommunications Development Programme as a joint initiative of the twelve island countries of the South Pacific Forum together with Australia and New Zealand, carefully co-ordinated planning and implementation of a programme of telecommunications development is now proceeding. The paper reviews the introduction of digital methods to the telecommunication systems of the South Pacific and identifies areas where the new methods will be introduced either in the short term or in the long term.

2. INTRODUCTION

It is to be hoped that any uncertainties which may have existed regarding the inevitability of the digital world will have been dispelled by the end of this Conference. However, the conclusions of the Conference will also reveal the very wide differences in the approach to the "wired city", the "wired nation" and, ultimately, the "wired world" depending upon the starting point. This paper discusses approaches which are possible in the South Pacific where the starting point is a very low density of telecommunications traffic of all kinds and an infrastructure which is inadequate and in many cases is out-moded. The end point must be national and regional telecommunication infrastructures which permit the "convergence" of the digital signals of telephone traffic, computer and other data inter-connections and entertainment (sound and vision broadcasting) to be distributed, switched and charged to meet the needs of the households and the business and government institutions of the South Pacific. Although there may be some views to the contrary, it is the writer's view that the potential advantages of many of the enhanced services now becoming available as a result of the digitalization of the basic telephone network are quite as great as is the telephone itself. One example lies in the use of the telephone system to switch and deliver electronic mail. Although there are quantifiable economic advantages to business operations with the introduction of such services in the high population cities of the world, it is also hard to refute the claim of remote outposts of the Pacific that they should also gain the benefit of this development-not for improved business profit but for quick and reliable delivery of private correspondence.

3. THE SYSTEM OPTIONS

It is no longer valid to plan improvements or extensions to the telecommunications system in any country or in any region without taking account of the impending computer and other data needs or of the entertainment signals which will be demanded by households in the immediate future. The South Pacific is no exception to this rule although the "immediate future" may take a little longer to arrive in Tuvalu than in Fiji.

It was natural that computer technology would flow into telecommunications. The processor units of the computer offer unique opportunities to improve earlier telephone switching methods and the modern stored programme control automatic telephone exchange is in reality a large and very powerful computer. At the subscribers' premises there seems little doubt that, in the long run, the telephone instrument will also house the home computer. In some cases the telephone/micro computer will be augmented by the same peripherals that are available for use with conventional computers but, more frequently, it will be interconnected to the home television receiver to gain access to a large screen, colour, display.

The "tools" of the equipment designers and of the system planners for the new telecommunication systems include:-

(i) ever larger scales of integration of active and passive circuit elements.

(ii) increasing use of digital transmission technology which is becoming obligatory for computer interconnections but is then invaluable for integrated signalling and transmission of telephone and telegraph traffic and which is of growing importance to the generation and distribution of the baseband signals of sound and vision broadcasting.

(iii) the new transmission systems - satellite radio and optical fibre cable. The latter demanding the use of digital signal methods and the former moving rapidly towards digital modulation of the radio carriers as well as towards digital channel multiplexing methods.

4. THE HARDWARE OPTIONS

In the South Pacific, the stored programme control systems, hopefully with steadily increasing switching speed and transmission bandwidth, will be largely unchallenged for use in the switching of what will be, initially, telephone and telegraph traffic but which will diversify quickly to include the same range of enhanced services which are already available in the larger industrialized cities of the world. The junction and trunk transmission systems must be capable of digital transmission and this will lead to the use of PCM multiplexing on existing cables, the use of digital radio systems, early introduction of optical fibre cable (including for short submarine connections) and ultimately the very widespread use of satellite connections for national services on top of the present almost universal use of satellite circuits for international connections.

The latter conclusion is perhaps the outstanding issue to be brought to attention in studying the hardware options for the digital world in the South Pacific. Speakers at the Pacific Telecommunications Council in recent years have been drawing attention to the technical and operational advantages of satellite delivery methods for telephone development in the area. With the dawning of the "Information Age" and the necessity to plan for high speed digital transmission initially to the cities but eventually to even remote subscribers, satellite and submarine optical fibre cable networks become, finally, the only acceptable transmission systems for connections across water paths.

5. SOUTH PACIFIC TELECOMMUNICATIONS DEVELOPMENT PROGRAMME

After one year of joint discussion the countries participating in the S.P.T.D.P. have endorsed the first of the rolling Three Year Programmes which will be used to guide the progress of the work of improving and extending the telecommunications infrastructure in the South Pacific.

With the establishment of this Three Year Programme it becomes possible to predict the main digital hardware purchases for the years 1985-1987.

* local network automatic exchange plant ranging from 50 lines to 3,000 lines and using digital stored programme control switching methods;

* small digital telex exchanges;

* rural radio and cable systems including digital radio concentrators;

* a trial submarine optical fibre cable system;

* the first of the optical fibre land cable systems;

* the use of the new "Vista" initiative of Intelsat to establish low traffic international connections to two island countries using digital demand assigned multiple access channelling for maximum economy in transponder useage and in space sector hire charges to the countries concerned.

The recently completed UNDP/ITU Telecommunications Manpower & Training needs Review had as its main purpose "..to provide each telecommunications administration of the South Pacific region with a credible and authoritative statement of their manpower and training requirements for the next decade..."

The working papers circulated following completion of the Review provide data which enables a strong case to be made for the use of system and hardware designs which permit savings in the number of skilled operating staff.

The use of digital switching concentrators for remote area subscribers services and maximum use of satellite methods for longer distance trunk or subscriber connections will all minimize the number of skilled staff required in the region.

5. CONCLUSION

There is no valid case for denying the use of digital methods in the development of the telecommunications infrastructure of the South Pacific. Use of the more advanced systems will not introduce price penalties in establishment costs, while savings in operating and maintenance expenditure will usually be gained. The social and economic advantages claimed for telecommunications of the past will be more generously available from the enhanced services of the near future and the new systems will be well placed for further development towards the wired nations and wired region of the 21st century. The most pressing need in the writer's view is for the earliest possible co-ordination of what is at present largely separated and uncoordinated planning and development of the three rapidly converging signal streams:- (i) telephone and telegraph (ii) computer and data (iii) entertainment - sound and vision broadcasting.

A STUDY ON THE SATELLITE BROADCAST SERVICE SYSTEM IN THE ASIAN AND OCEANIAN REGIONS

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ABSTRACT

This paper proposes a satellite broadcast service system for the Asian and Oceanian regions, not as an alternative overseas satellite broadcast system to existing terrestrial overseas broadcasting systems, but as a system in which each country would have its own broadcast programs. First, the present broadcasting situation in the Asian and Oceanian regions is surveyed and analyzed, in conjunction with the size of population and national incomes in various countries. Second, the necessity for a satellite broadcast system to countries either without a TV broadcasting system or only limited TV broadcasting hours or having an insufficient spread rate of TV sets is discussed. Third, the possibility of establishing a satellite broadcast system is studied. The broadcast countries are supposed to be 7 countries in the Asian region and 8 countries in the Oceanian region. The following system parameters are examined. Reception system: Community reception. Frequency band: 14/12.5 GHz band. Satellite geostationary location: 125 degrees east longitude. Finally, the configuration of a broadcast satellite, AOSAT, and its on-board transponder is presented.

1. INTRODUCTION

First of all, we will describe the idea behind a regional broadcast system. Global communications system using the satellite is provided by INTELSAT. The domestic satellite communications systems are provided by US's WESTAR and SATCOM, Canada's ANIK, Japan's CS-2 and so on. Regional satellite communications systems are operated or planned as the system intermediate between global and domestic. Europe's ECS and Indonesia's PALAPA are typical examples of systems which are operated. ARABSAT, for 22 Arabic nations, is an example of a planned system.

On the other hand, in the Pacific Ocean area, the PEACESAT system using NASA's ATS-1 has been configured so far(1). Since ATS-1 was launched in 1966, its operation will be ceased soon. Thus, a regional satellite communications system was examined to maintain communications in the Pacific Ocean area(2).

Concerning the broadcast system, the necessity of making the broadcast in the Asian region substantial was recognized at the Forum on Broadcasting and Information Processing, which was held in commemoration of the World Communications Year in 1983. Satellite broadcasting systems in the Asian region include India which started its satellite TV broadcast services using INSAT and Indonesia which has conducted the transmission of broadcast programs using PALAPA. ARABSAT also include broadcast services. Furthermore, in the Oceanian region, Australia's AUSSAT will include a broadcast service to the Papua New Guinea region as well as throughout Australia through community reception(3).

Taking into account the communication/broadcast satellite systems in the Asian and Oceanian regions examined so far, we intend to study a broadcast service system in the Asian and Oceanian regions as a study model for a wide area broadcast service using the satellite. The reasons for this study are as follows. Although the satellite communications systems, in these regions, have been examined in relative detail so far, a satellite broadcast system in this region has not yet been studied. Broadcasting, especially TV broadcasting, is an important step in improving nation's education and advancing its culture. Nevertheless, there are fairly many countries which have no TV broadcasts. We believe that not only high level technology but also high capability of program production of Japan can contribute to such countries. Satellite broadcasting systems, examined in this paper, are not an overseas satellite broadcast service as an alternative to existing terrestrial overseas broadcast services, but a system in which each nation would have its own broadcast programs. Therefore, we envision a broadcast satellite system which can be commonly used by a number of countries. However, needless to say, such a system must be examined carefully bearing in mind that viewers are in a passive situation.

The contents of this paper are independent from the policy measures of the Ministry of Posts and Telecommunications, Japan and are only intended as a technical study.

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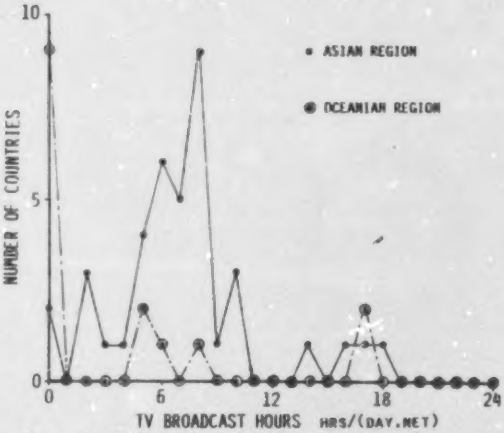

Fig. 1. TV broadcast countries and hours.

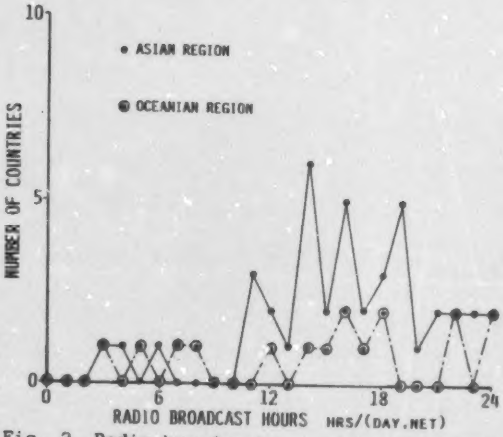

Fig. 2. Radio broadcast countries and hours.

2. PRESENT BROADCAST SITUATION IN THE ASIAN AND OCEANIAN REGIONS

The present broadcasting situation(4)(5) was surveyed in 41 Asian countries and 16 Oceanian countries, provided that territories were counted as countries. An analysis of the present broadcasting situation was made and the results are shown on the charts, which are the basis of selecting suitable countries for the proposed broadcasting system.

(i) Broadcast hours

As a result of this survey, we noticed that the broadcasting in the Asian and Oceanian regions is not carried out all day long or from early morning to midnight as in Japan. The relationship between the number of countries and TV and radio broadcasting hours are shown in Figs. 1 and 2, respectively. The unit of broadcasting hours is the broadcasting hours per day per network, hrs/(day.net), over an average week. Figure 1 shows that the peak TV broadcasting hours are at 0 hrs/(day.net), which means no TV broadcasts, and approximately 6 and 8 hrs/(day.net). Figure 2 shows that the peak radio broadcasting hours are at approximately 11, 14, 16 and 19 hrs/(day.net).

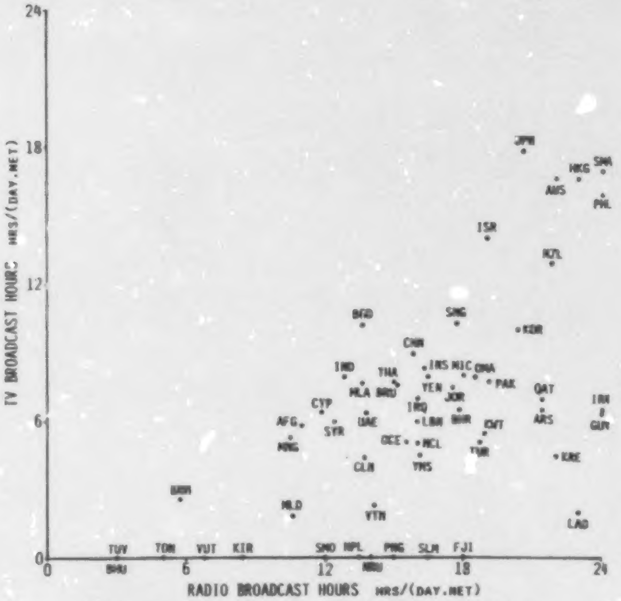

Fig. 3. TV and radio broadcast hours.

Figure 3 shows the relationship between TV and radio broadcast hours to indicate the total broadcast hours for each country. The country symbols are defined in Table 1. A gravity center of broadcasting hours, in Fig. 3, is placed at 6.4 hrs/(day.net) of TV broadcasting and 15.9 hrs/(day.net) of radio broadcasting. It should be particularly noted that there are some countries in the Oceanian region, such as Fiji, Kiribati, Nauru which have no TV broadcast service. However, among these countries, Fiji and Solomon Islands have more than 16 hrs/(day.net) of radio broadcasting. There are also several countries in the Asian region, such as Bhutan and Nepal which have no TV broadcasting and have relatively short radio

Table 1 Symbols of Countries.

ASIAN REGION	
AFG	Afganistan
ARS	Saudi Arabia
BGD	Bangladesh
BHR	Bahrain
BHU	Bhutan
BRM	Burma
BRU	Brunei
CBA	Cambodia
CHN	People's Republic of China
CLN	Sri Lanka
CYP	Cyprus
HKG	Hong Kong
IND	India
INS	Indonesia
IRN	Islamic Republic of Iran
IRQ	Iraq
ISR	Israel
JPN	Japan
JOR	Jordan
KOR	Republic of Korea
KRE	Democratic People's Republic of Korea
KWT	Kuwait.
LAO	Lao People's Democratic Republic
LBN	Lebanon
MAC	Macau
MLA	Malaysia
MLD	Maldives
MNG	Mongolia
NPL	Nepal
OMA	Oman
PAK	Pakistan
PHL	Philippines
QAT	Qatar
SNG	Singapore
SYR	Syrian Arab Republic
THA	Thailand
TUR	Turkey
UAE	United Arab Emirates
VTN	Viet-Nam
YEN	Yemen Arab Republic
YMS	People's Democratic Republic of Yemen
OCEANIAN REGION	
AUS	Australia
FJI	Fiji
GUM	Guam
KIR	Kiribati
MIC	Micronesia
NCL	New Caledonia
NRU	Nauru
NZL	New Zealand
OCE	French Polynesia
PNG	Papua New Guinea
SLM	Solomon Islands
SMA	American Samoa
SMO	Western Samoa
TON	Tonga
TUV	Tuvalu
VUT	Vanuatu

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broadcasting hours. Another feature is that Burma and Maldives have short TV and radio broadcasting hours.

Hereupon, we intend to analyze the broadcast hours in connection with other factors, focussing on the countries mentioned above. Only TV broadcasts will be treated in the following.

(ii) Broadcast hours versus national incomes

We have taken the national income per person as a measure of the standard of life in that country. Figure 4 shows the relationship between TV broadcast hours and national incomes. A solid line in Fig. 4, calculated by linear regression, indicates that the smaller the national incomes, the shorter the TV broadcast hours. The broadcast hours may relate to the policy of that countries. On the other hand, the lack of TV broadcasts in another country, with an extremely high national income, may be due to technical problems.

There is evidence that the number of countries with shorter broadcasting hours increases, when the national income is less than 500 dollars a year per person.

(iii) Population size versus broadcast hours

Figure 5 shows the relationship between the size of population and the TV broadcast hours. A regression line in Fig. 5 indicates that the smaller the population, the shorter the broadcast hours. Conversely, a reasonably large population has an increased number of broadcasting hours.

(iv) Number of TV sets versus broadcast hours

The relationship between the number of TV sets and broadcast hours is shown in Fig. 6. A regression line in Fig. 6 shows the fewer the number of TV sets, the shorter the broadcast hours.

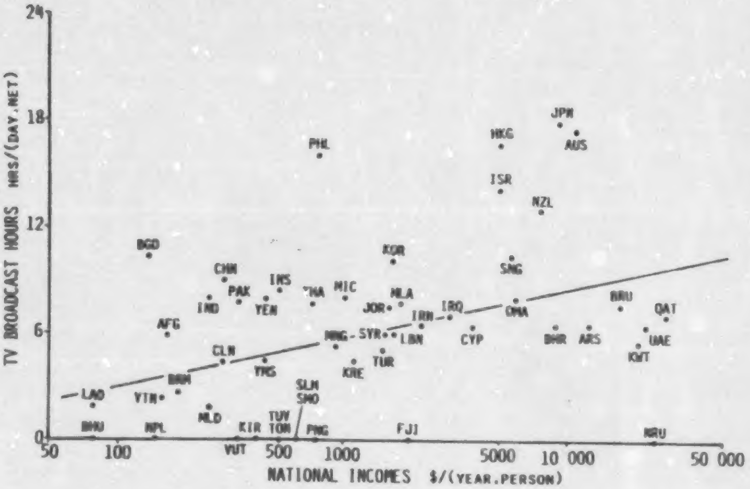

Fig. 4. TV broadcast hours vs. national incomes.

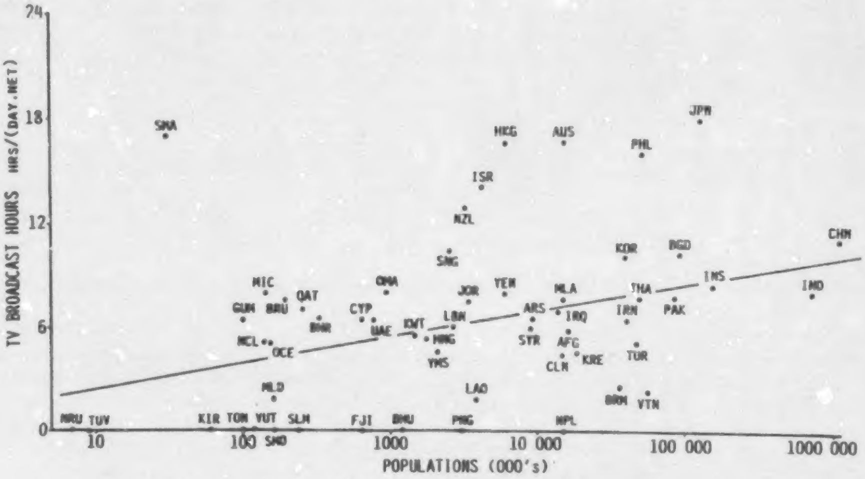

Fig. 5. TV broadcast hours vs. populations.

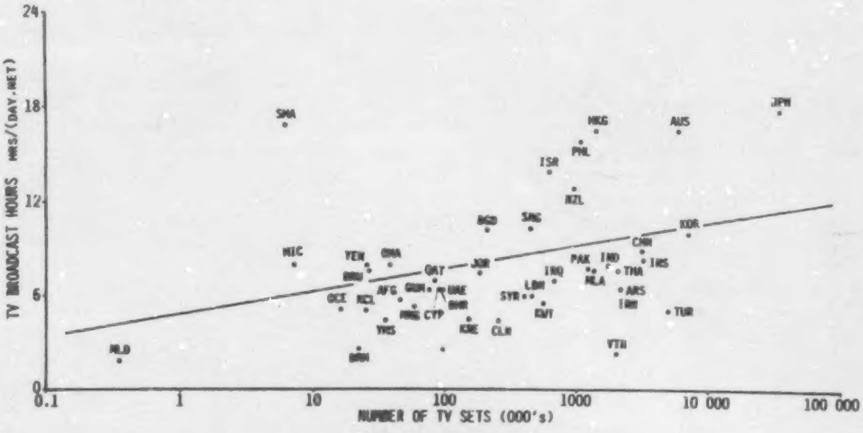

Fig. 6. TV broadcast hours vs. TV sets.

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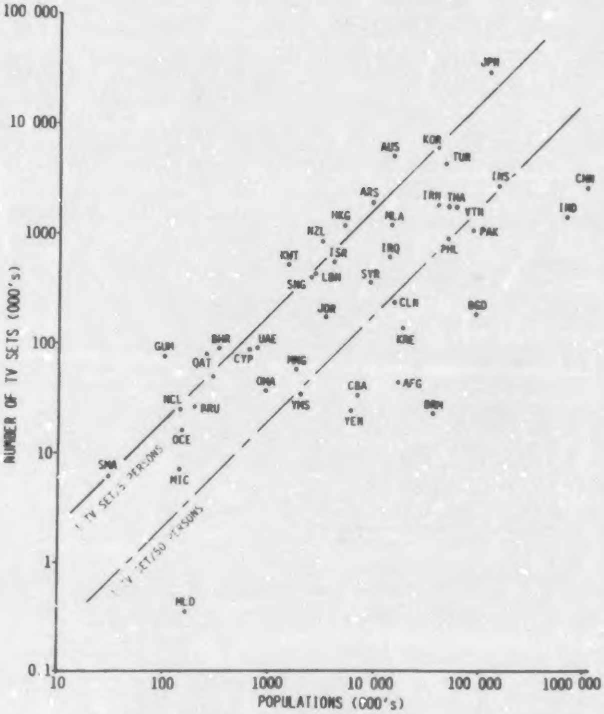

Fig. 7. TV sets vs. populations.

(v) Number of TV sets versus population size

The relationship between the number of TV sets and the size of population is illustrated in Fig. 7. In order to clarify the spread rate of TV sets, a solid line, in Fig. 7, shows a spread rate of one TV set for 5 persons, which is approximately one TV set per household and a broken line, in Fig. 7, shows the spread rate of one TV set for 50 persons, which is approximately one TV set for 10 households. In this paper, we consider countries which are below the broken line as countries with a very low spread rate of TV sets. Most of the countries below the broken line have national incomes of less than 500 dollars a year per person referred to Fig. 4. Therefore, the spread rate seems to be consistent with the national income.

3. NECESSITY FOR SATELLITE BROADCASTS

We will examine the necessity for a satellite broadcast service, based on the present broadcasting situation in the Asian and Oceanian regions. For the purpose of this paper, we have considered that satellite broadcasting is needed for countries either without TV broadcasts or with short TV broadcasting hours and a very low spread rate of TV sets. However, it should be mentioned that this is only the authors' view.

Most countries in the Oceanian region without a TV broadcasting service are newly independent and the installation of terrestrial broadcast facilities has probably been delayed. Since these countries have many islands which cover a large area, it would be difficult from a technical point of view to provide broadcasting services throughout the nation, using terrestrial facilities. However, most of these countries do have relatively long radio broadcasting hours. We can therefore assume that if TV broadcasting was available, TV services would spread. The countries in the Asian region without TV broadcasting service, have national incomes of around 100 dollars a year per person. We assume that economical reasons prevent such countries from starting their own TV broadcasting service. There is the added consideration that TV broadcasting using terrestrial facilities would be difficult due to the mountainous areas in those countries.

The countries which only have short broadcast hours or a very low spread rate of TV sets have small populations or have national incomes of less than 500 dollars a year per person as mentioned in Chapter 2. In this situation, if Japan produced programs under contract to these countries and broadcast the programs through a satellite, a positive contribution to these countries, both educationally and culturally, could be expected.

4. SATELLITE BROADCAST SYSTEM

4.1 Selection of Broadcast Countries

Suitable countries for a satellite broadcasting service were selected as follows. A joint set of countries is obtained from the countries which either has less than 4 hrs/(day.net) of TV broadcasting hours or has a very low spread rate of TV sets. Countries, which are not independent or which either have their own broadcast satellite or whose policy might limit the TV broadcasting, are subtracted from the joint set. As a result, 7 countries in the Asian region and 8 countries in the Oceanian region were selected.

4.2 Requirements for the Satellite Broadcast System

We considered a system which would broadcast to the selected countries, using a single broadcast satellite. The broadcast programs would either be produced at the request of the country or under its own supervision. The programs would then be converted to video and audio signals and transmitted to the broadcast satellite through an earth station in Japan. The satellite would broadcast the signals to the country at the appropriate frequency and the signals from the satellite would be received by community reception systems. The satellite parameters were optimized(6) and as a result, the following system parameters were selected. Frequency band: 14/12.5 GHz band. Satellite geostationary location: 125 degs. E. Satellite antennas: Multi-beam antennas of 6 fixed beams. Number of broadcast channels: 8 (one for each country in the Asian or Oceanian region). Broadcast hours: 12 hours a day for each country on a shared basis between the Asian and Oceanian countries. Total satellite transmit power: 195 W (max.). G/T of reception facilities: More than 18.5 dB/K, preferably 21.4 dB/K.

Table 2 Satellite Broadcast System Parameters.

COUNTRY	EAST LONGITUDE	BEAM NUMBER	BEAMWIDTH °	TRANSMIT POWER(W)
PAK	73°	1	2.5°	30.4
NPL	85°	1	2.5°	30.4
BHU	90°	1	2.5°	30.4
BGD	90°	2	2.5°	30.4
BRM	96°	2	2.5°	30.4
MLD	74°	3	2.1°	21.5
CLN	80°	3	2.1°	21.5
SLM	160°	4	2.1°	21.5
NRU	167°	5	2.1°	21.5
KIR	172°	5	2.1°	21.5
TUV	178°	5	2.1°	21.5
VUT	168°	6	2.1°	21.5
FJI	178°	6	2.1°	21.5
TON	184°	6	2.1°	21.5
SMO	188°	6	2.1°	21.5

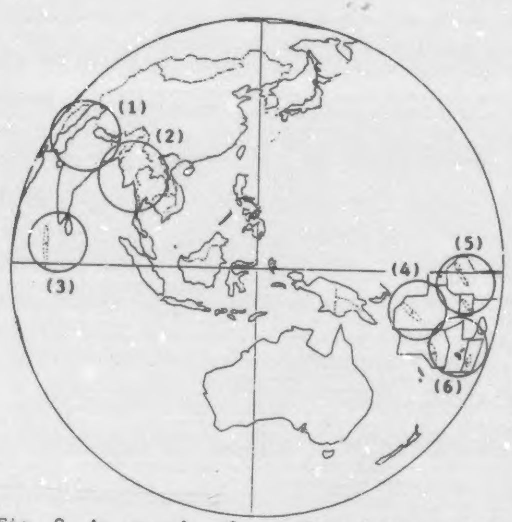

Fig. 8. An example of satellite beam coverage.

Table 2 shows the antenna beamwidths and satellite transmit power needed to satisfy the power flux density limitation of -111 dBW/m^2 at each of selected countries. The countries with the same beam number in Table 2 are covered by the same antenna beam. The beam coverage is shown in Fig. 8. The satellite system also needs another antenna beam to Japan.

4.3 Configuration of the On-board Transponder

The satellite broadcast system requires an on-board transponder as shown in Fig. 9. This transponder can broadcast either to the Asian region or to the Oceanian region.

A typical channel plan is shown in Fig. 10 with channels shared by the Asian and Oceanian countries whose longitude difference is approximately 90 degrees which correspond to a time difference of 6 hours. The neighbouring downlink channels use the orthogonal polarization in order to prevent channel-to-channel interference.

4.4 Parameters of the Space Segment

An example of the satellite parameters is shown in Table 3. The cost for this space segment is estimated to be around 210 million dollars ('84 US $). Figure 11 shows an artist's conception of the satellite in orbit which we have called "[illegible]SAT".

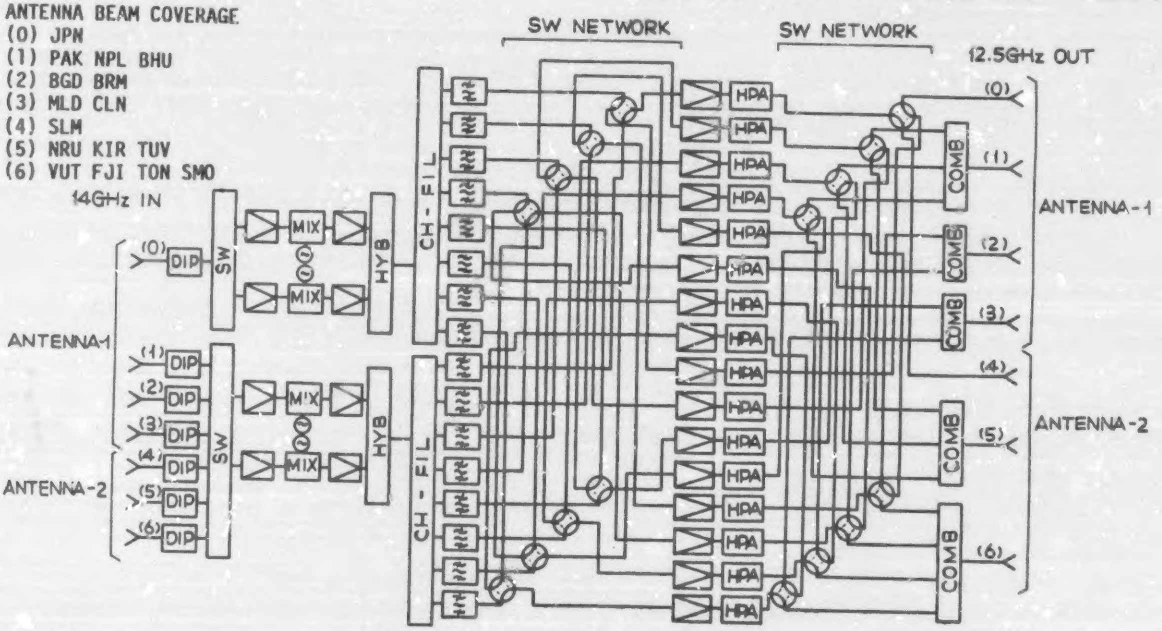
ANTENNA BEAM COVERAGE
(0) JPN
(1) PAK NPL BHU
(2) BGD BRM
(3) MLD CLN
(4) SLM
(5) NRU KIR TUV
(6) VUT FJI TON SMO
14GHz IN
ANTENNA-1
ANTENNA-2
(0)
(1)
(2)
(3)
(4)
(5)
(6)
DIP
SW
MIX
HYB
CH - FIL
SW NETWORK
SW NETWORK
HPA
COMB
12.5GHz OUT
ANTENNA-1
ANTENNA-2

Fig. 9. An example of transponder.

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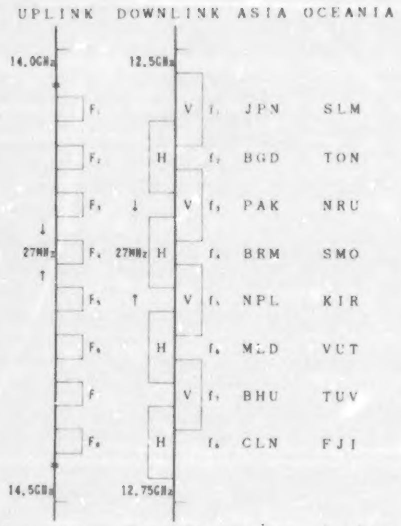

Fig. 10. An Example of channel plan.

Table 3 An Example of Space Segment Parameters.

Satellite bus	Hughes HS376 equivalent
Launch vehicle	PAM-D class
Satellite life	7 years or more
Orbital locations	125 degrees east longitude
Eclipse capacity	100% (2 x 28.5 Ah NiCd batteries)
Satellite dry weight	508 kg
Solar panel capability	954 Watts (EOL Summer Solstice)
Satellite antenna and attitude control	Platform despun antenna Beam pointing accuracy 0.2 deg./0.05 deg. (without/with RF tracking)
Mission weight	107 kg (transponder) 29 kg (2 x 80 cm diameter antennas)
Mission power	730 Watts
Transponder	Uplink (14 GHz band) 8 channels from Japan and 8 channels from broadcast countries Downlink (12.5 GHz band) 1 channel to Japan and 8 channels to broadcast countries

5. CONCLUSION

This paper describes the proposed AOSAT, Asian and Oceanian Regional Broadcast Satellite. The satellite broadcast service will contribute to the education, advancement of culture and training of technical talents. Needless to say, the requirements of individual countries are needed. A proposal, "Principles governing the use by states of artificial earth satellites for international direct television broadcasting", was proposed and adopted at the 37th United Nations General Assembly. The developing countries supported the proposal for the following reasons. A direct broadcast satellite system would result in the unidirectional communication of information from the transmit country. Such communication would cause a fear of preventing the developing countries from implementing the cultural unification. Therefore, at least agreement made by the countries receiving the TV broadcasts is needed in advance.

Although there is a risk of an unwelcome influence from satellite broadcasting, we believe that the merits of the satellite broadcasting are desired.

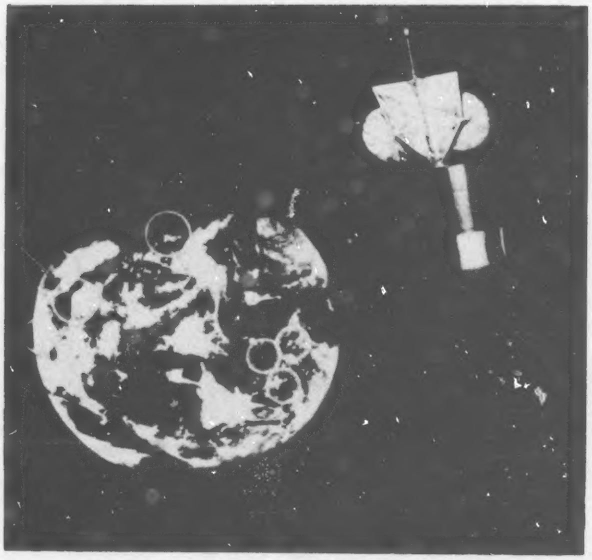

Fig. 11. Artist's conception of AOSAT.

It is the most important therefore that we continue our effort to implement such a satellite broadcasting system, taking due consideration of the problems mentioned above.

The study refered to earlier in this paper was based on the paper(6) which was awarded the first prize in a research promotion contest held by the Association for Promotion of International Cooperation, Tokyo, Japan in March 1984.

ACKNOWLEDGMENT

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TRAINING IN THE WORLD OF THE INTEGRATED SERVICES DIGITAL NETWORK

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ABSTRACT

The implementation of new technology will have major effects on the telephone industry. A thorough working knowledge of this technology and it's issues will be vitally important from the planning stages to implementation. This paper will address the issues and impacts of this new technology from a training viewpoint and offer solutions to those problems.

1. INTRODUCTION TO THE KEY ASPECTS

The full impact of digital technology on the telecommunications networks of the world was brought into focus with the definition of an Integrated Services Digital Network (ISDN) by the CCITT. While some of the techniques and services which form part of the general ISDN concept were being proposed quite seperately for the networks of individual administrations & Recognized Private Operating Agencies (RPOA's), the development of a widely accepted set of standards by CCITT has turned the trickle of potential changes into a torrent.

The changes now being proposed involve more than the addition of some new network components. They, in fact, affect the total structure and operation of the network and the business environment in which the industry operates. This in turn will impact on the people involved in the various facets of the telecommunications business who will have to handle the new techniques and services. The training process to facilitate this changeover must also be adapted to meet the challenge of the Integrated Services Digital Network.

The major factors to be considered in the preparation of new training programs are:

- THE SCOPE OF THE NETWORK CHANGES
- THE RATE OF NETWORK CHANGE AND SERVICE INTRODUCTION
- THE NUMBER OF PEOPLE INVOLVED AND TYPES OF SKILLS
- THE CHANGING BUSINESS AND REGULATORY ENVIRONMENT

2. CURRENT APPROACH TO TRAINING

As a general rule, training today tends to be directed at narrow and specific job applications. This has been effective since in many cases the very job assignments themselves tend to be quite structured in their nature. A training program in digital concepts would be of very little use to a cable splicer, or a course in pole climbing would be of little use to a service order clerk. For job specific situations this is, as a rule, a fairly efficient approach.

With the predicted changes to the network this segmented and isolated approach to training can have some limitations. For example, the splicer is likely to find his splicing role changed and possibly reduced with the introduction of fiber optics to replace metallic circuits. As a result he may have the scope of his work broadened to include aspects of maintenance or he could be reassigned to completely new work. Preparation for the change should be introduced by some broadening of his basic skills.

Training today tends to have very few "broad scope" courses. This introduces significant duplication of effort. In the early days of common control switching there was a requirement for a working knowledge of digital logic and computer fundamentals for specific craft personnel. In most cases the actual equipment training was used as a vehicle to develop these "broad scope" skills. These same skills were required in other areas such as transmission engineering/planning. The same approach of including the basic skill training with the actual equipment training was used. In most cases these courses were developed and delivered by different trainers, sometimes in different groups. We then have a case of common skill sets and duplicate training.

A second aspect of a lack of "broad scope" programs is rather intrinsic. An appreciation of the nature of the entire network would be of some benefit to everyone who is responsible for a part of that network. For example, that same knowledge would assist various levels of management in the execution of their financial and personnel responsibilities.

The methodology of today's training also bears some examination. Today's training is, for the most part, trainer driven rather than trainee driven. In this case the training is seldom mapped to the individual trainee's speed nor his individual learning requirements.

One other important factor to consider is the approach used in much of of today's training development. That approach, in many cases, is reactionary. Training requirements are not fully examined before changes in the workplace are implemented. Training then becomes a solution to a problem rather than a means of problem prevention. To demonstrate, let's examine a particular development methodology.

There are six stages in this training development process.

1. The needs study.
2. Task analysis.
3. Material production.
4. Formative evaluation.
5. Pilot program.
6. Summative evaluation.

When we further examine the needs study stage we see the following sub processes:

1.1 Identification of performance discrepancies.
1.2 Quantification of performance discrepancies
1.3 Definition of performance discrepancies.
1.4 Classification of performance discrepancies.
1.5 Generating alternative solutions to performance discrepancies.
1.6 Estimate the cost of implementing the alternative solutions.

Since the "need" is clearly directed at overcoming an identified deficiency in performance it is obvious that this particular type of methodology is designed for a reactionary approach. This methodology works very well for established jobs and functions but has limitations when applied to general knowledge or undefined jobs or functions.

3. THE TECHNOLOGICAL AND REGULATORY IMPACTS OF THE INTEGRATED SERVICES DIGITAL NETWORK.

- Digital systems are replacing analog systems in switching, transmission and surveillance. Computers and software will be the backbone of these systems.

- Separate services with separate networks and mixed services on common facilities will evolve into a fully integrated network that provides voice, image and data services.

- New and different customer terminal apparatus and wiring arrangements will be required.

- Customer Premises Equipment (CPE) will no longer be an integral part of the network. There will be a fully defined interface point. Most CPE will be customer owned. Customers will have more control of the equipment.

- Personal computers, local area networks, intelligent terminals and compressed video technology will provide new service opportunities.

- New performance criteria will be established (Error Free Seconds, Bit Error Rate, Slip, Delay, Jitter). This will require more sophisticated real time surveillance. The regulators will require proof of performance.

- National, International and Regional standards activities are expanding. These standards are not all currently in a stable form and there will be some changes to existing standards as new standards are established.

- There will be effects of new regulations on network/user responsibilities, network management, fault location and load planning.

- The use of packet technology for control circuits and systems (D Channel, CCS7, X.25). A further complicating factor is integration of packet data handling into these signalling/control systems.

- There will be new digital signal coding techniques to facilitate bit reduction, error control and line signals for different transmission media.

- There will be the application of low bit rate encoding and digital speech interpolation for more efficient transmission.

- There will be interworking between specialized networks using different protocols, numbering plans, physical interfaces and other standards.

- Changes to traffic patterns, switching hierarchy and tariff arrangements will be significant.

- An opportunity will evolve for intelligent service provisions by the Telcos or independent service providers.

4. THE ORGANIZATIONAL IMPACT OF THE NEW NETWORK

The impact on people will be significant. Many new types and levels of skills will be required. There will be organization changes required to reflect the integration of the new technology and the associated business arrangements of the future network.

To examine this we have broken a typical telephone company organization into five very broad strata.

a. MANAGEMENT AND STRATEGIC POLICY MAKERS

- An improved understanding of the basic technology will be required to cope with the future network evolution.

- Future time frames for policy decisions will be drastically shortened from today's.

- The business strategies must be flexible to adapt to service and regulatory changes.

- The shift in organizational structure to manage the new network will create problems of adaptation for employees.

b. MARKETING AND SALES

- Current marketing and sales skills may require enhancing to handle the broad range of new services from an integrated network.

- Changing tariff and regulatory arengements will require new marketing skills to handle the split between regulated and unregulated services.

c. NETWORK PLANNERS AND STANDARDS & METHODS GROUPS

- Technical skills will need updating. Existing and new elements will coexist in the network and problems of compatability and interworking will occur.

- More critical and costly decisions affecting the growth of the network will have to be made with less marketing data and within shorter time frames.

- Planning must include the provision of both the network additions and fully trained support staff.

d. CRAFT AND PLANT/LINE MANAGEMENT

- Current technical skills will become obsolete as the network evolves from analog to digital and into an ISDN.

- Jobs will become less narrowly defined. People will be expected to move more readily between jobs requiring different skills.

- Integrated services will require a better knowledge of associated jobs. A wider range of basic skills such as digital or computer technology fundamentals will be required.

- Many jobs will require more extensive computer skills for the newer facilities using extensive micro-computer control, surveillance and analysis techniques.

e. ADMINISTRATIVE SUPPORT

- Skill and knowledge levels required for services provided in the current network will require enhancement for integrated services. The network/user relationships will change significantly.

- Financial accounting will have to be on a more real time basis due to time and tariff implications. The issue of usage sensitive pricing and customer selection of services on a real time basis are likely to call for improved billing and service facilities.

- Personnel policies may not be adequate to support the changing organization and increased flexibility of staff assignments. We are already seeing signs of more sophistication in the workforce.

5. THE TRAINING PROBLEMS

The training problem is, in essence, the inability of many of the current approaches, methodologies and delivery media to address the significant training needs caused by the future network. We can reference this to our four key issues that were defined in section 1.

a. THE SCOPE OF THE NETWORK CHANGES

The specific changes to the network, which are ongoing, affect all areas of the network. These changes are the result of the introduction of digital switching and transmission systems and from the impact of the ISDN concept. As an example, the Telecom Canada network which first introduced T1 carrier into local inter office networks in the early 1960's, has had a rapid penetration of digital switches in the toll network in the last decade (about 50% of the toll terminations are expected to be digital by 1985) and digital transmission facilities in both the local network and in the intertoll network should bring the percentage of digital circuit Kilometers to over the halfway mark by 1985. Common channel signalling is expected to be introduced within the same time frame.

These changes to the core network are critical for the evolution to ISDN, however much wider changes are required to support the overall ISDN concept. The major impact will be in the local network. The ISDN standards require digital access between the user and the network to facilitate higher speed data traffic and improved procedural capabilities. This will also impact on customer premises wiring and the design of new terminal devices.

Local switches must be enhanced to handle the new traffic from these improved access facilities. Many of these switches will be fully digital by the late 1980's, however service capabilities to those areas served by analog switches can also be expanded. In particular, there must be arrangements to provide the user with a perception of integrated voice, data and possibly image telecommunications.

The introduction of integrated facilities will require an integrated numbering plan, improved service monitoring and billing facilities down to the local exchange.

The intelligence provided by the Central Processors of modern switches is being supplemented by peripheral computers and centralized data bases. Enhancements will be provided to existing telephone services. Customer service profiles will be stored, as will information on the status of the network. Customer's traffic can be stored or processed either within or via the network. Integration of voice, data and image traffic will enable common usage of these added intelligence capabilities for a wide range of new services.

These changes are expected to be the start of the network evolution. Technology has the ability to provide a much more dynamic network, shaping channels to meet a customer's needs. It is only the size of the network which limits the speedy introduction of such capabilities. However, the process will not stop and we must prepare for a continuation of the evolutionary process.

b. THE RATE OF NETWORK CHANGE AND SERVICE INTRODUCTION

The telephone network has traditionally lagged the computer industry in the incorporation of new technology, the enormous capital investment in plant being the main reason. The implementation of ISDN will shorten that lag since ISDN concepts and techniques will allow interworking with much of the existing network in an ISDN.

The following table shows the expected evolutionary phases of ISDN for the foreseeable future.

ISDN Evolutionary Phases

Transition 1984 to 1986
- Pre-ISDN Services using transitional techniques.
- Separate access facilities -- alternate voice and data.
- Expanded digital loop and switching capability.
- Increased penetration of Common Channel Signalling.
- 64KBit/s clear channel capability.

First Generation 1986-1990
- Integrated digital access.
- CCITT standard equipment and user/network interfaces.
- Simultaneous voice/data at 64 KBit/s.
- Expanded customer control -- D channel signalling.

Second Generation 1990 and beyond
- Wide band voice and high speed data.
- Integration of circuit and packet switching.
- New services including subrate and broad band switched services.

As we can see it may be less than two years to the implementation of some aspects of ISDN. There will be some major problems in addressing training in this time frame.

The time aspect of digital capability introduction further demonstrates this problem.

In many cases there will be the need to make the training development process run parallel to the definition of system and network standards in order to shorten the delay from training definition to delivery. This will be necessary since many equipment and terminal manufacturers will be introducing new ISDN products as soon as the standards definition is approved.

c. THE NUMBER OF PEOPLE INVOLVED AND THE TYPES OF SKILLS

Since the future network will have far-reaching impacts there will be very large numbers of people affected.

In 1983 there were approximately 100,000 people in the telephone industry in Canada. If we extrapolate that figure, there are over a million telephone workers in North America. If we hypothesize that half this population requires a 1 day overview of ISDN then 50,000 student/weeks of training would be required. That is the equivalent to all the class time required to send 500 people through a 4 year university degree program. And this just addresses the telephone companies. If we consider the telecommunications terminal manufacturers also, the numbers become even larger.

There has been a relatively low level of new graduate hiring in the telephone industry in the past five years, particularly in engineering areas. Retraining in state of the art technical skills will, therefore, be needed for existing personnel.

The types of skills needed are as broad as the impacts that have been mentioned. Some specifics will be addressed in Section 6 (Solutions to the Training Problems).

d. THE CHANGING BUSINESS AND REGULATORY ENVIRONMENT

ISDN will bring some significant changes in the telecommunications business environment.

Regulated and unregulated services will co-exist in a single network. There will be problems that arise from inter exchange and equal access regulations. There will be problems in the area of separation of customer/network responsibilities and ownership. On-going training will be required to address these issues.This could be further complicated since the nature of the marketplace and customer demands will change as the new services are available and implemented.

At present there are 7.9 million residential and 1.5 million business telephones in Canada. That represents a business opportunity of 9.4 million potential customers for digital services. Digital end-to-end services in the United States is expected to be a 31 billion dollar business and the U.S. installed base of terminals is expected to reach 31 million by 1990. These business potentials demonstrate the need for good sales/marketing skills and training. They also emphasize the numbers aspect discussed earlier in this section.

e. OTHER TRAINING CONCERNS

Obtaining timely and accurate documentation on the applications of new technology will be a serious problem in the definition and development of training materials.

Dynamic training programs for management and strategic planners will be a priority to ensure that they keep up with the evolution of ISDN and it's new technology.

The cost effectiveness of current training development and delivery methods will require a detailed examination. Not only must the training costs be considered in more depth but the travel costs and manpower costs of the trainees must be closely scrutinized.

6. A PROPOSED SOLUTION TO TRAINING

We have reviewed the implications and defined the problems that will come with the implementation of ISDN. We must now identify the solution.

We have indicated that current training development methods are reactionary - a response to an existing problem. It is clear that to plan for the future we must see training programs as part of the preparation for change rather than a response to change.

An in depth analysis of projected skills must be the first step of the training process and it must cover all aspects of the business. Obviously the first people in the organization to be introduced to the ISDN concept and its impact on the industry will be the corporate planners and the trainers. They must identify the corporate training needs as part of the future business planning and initiate the program. They must provide justification and direction to the process.

WHO do we train?

Our analysis indicates that a vast majority of personnel in the telecommunications industry will be affected. Lets make an assumption, for initial planning purposes that we direct our attention at the broad groups defined earlier in section 4. i.e.

1. MANAGEMENT AND STRATEGIC POLICY MAKERS
2. MARKETING AND SALES
3. NETWORK PLANNERS AND STANDARDS/ METHODS GROUPS
4. CRAFT AND LINE MANAGEMENT
5. ADMINISTRATIVE SUPPORT

In each of these areas we must identify WHO specifically requires training, the particular skills area, and the level of skills required. It should be noted that in view of the rate of change in the technology and the business environment this "needs" review must be reexamined on a periodic basis.

WHAT training do they need?

All of these groups need some knowledge of ISDN but ISDN to a Vice-President, Planning is not the same as ISDN to a C.O. technician. Our first task is then to define ISDN with reference to our five basic groups. That definition, along with assumptions of current skills, will define the starting point for our training.

ISDN to a senior manager or strategic planner is a response to the changing business environment. It is the business planners stock in trade. They require basic technical knowledge of ISDN, but more importantly they have a need to be aware of the business and technical implications and developments in technology and the changing business environment. Training for this group will have to be a dynamic process. As the changes occur there will be a need to disseminate this information to the senior management and planners.

ISDN to the sales and marketing functions represents a business opportunity. They will also require some basic technical information but their emphasis will be on the services, both regulated and unregulated, that will be provided in an ISDN. A dynamic training process for this group will also be important. ISDN will allow the provision of new and different services. A more market driven business will evolve. It will be important that the market trends be identified so the senior management/policy makers can make the best decisions.

ISDN to the network planners and standards/methods people is a framework for network evolution. This group will require detailed technical information as fast as possible from the time of definition. In many cases these people will have to speculate on future developments and standards. A comprehensive overview of ISDN is imperative for this group. Training programs that address currently written standards such as interfaces and protocols (CCITT I series and Q series recommendations) are also needed with a certain urgency. There is also the need for a forum to ensure that these people are aware of ongoing development in areas such as loop technology, digital encoding techniques, switching techniques and transmission methods and media.

ISDN to craft and plant is an operational revolution. Digital techniques, computer fundamentals and data transmission fundamentals surface as the cornerstone of their training needs, due to the digital nature of the entire network. These basic skills are also easily identified as prerequisites to any specific equipment training that will follow. As we examine the situation, other "broad scope" generic training starts to become evident such as acquiring an basic understanding of Interface standards, D channel and CCITT #7 protocols, loop technology, customer wiring arrangements and new performance parameters.

ISDN to a generic group such as administrative support would need as many definitions as there are job functions. Accountants and service order clerks would obviously have different needs. It is safe to assume, though, that most people will be affected and the minimum exposure would be an ISDN appreciation course.

HOW should the training be provided?

The scope and pace of network evolution has indicated the size of the job and demonstrates the need for new techniques. However the technological changes which are causing the problem may also be providing some of the answers. Computer technology provides ready access to a large information base on an industrial basis, as and when required. It will store, sort and structure information and may be updated on a real time basis. If this is tied to the new communications capabilities we have some of the basic tools for the new training approach.

It is clear however that the development of these tools takes significant resources, which may not be available in house. In addition, many skills are common to the industry rather than to only the individual organization. The training programs may then be built around a combination of in house and vendor supplied training packages integrated into one cost effective offering. These packages will require regular maintenance as technological advances are made and the business situation changes.

These training packages must combine classroom sessions and individually programmed learning based on access to suitable terminals. Simulation of real life problems, situations and operational exercises will provide a replacement for the hands on training that was used in the past.

WHEN should ISDN training commence?

We are already in the era of digital networks, although various organizations are at different levels of implementation. Therefore training for conversion from analog to digital skills and understanding should be underway at this time.

A number of services for which ISDN is intended to be the vehicle are already being implemented with transitional techniques, which have incorporated much of the early ISDN thinking, if not all of the specific standards. Thus in some ways the ISDN is on us right now.

The initial set of ISDN standards were approved by the CCITT Plenary meeting in Spain in October 1984, and work is already underway in the new session. As new standards are developed the speed of ISDN introduction will increase. It is expected major network changes with a wide penetration of ISDN philosophy and services will occur in the 1986-1990 time frame. Both operating companies and manufacturing organizations will be faced with making business decisions and preparing to support the the rapid network evolution. It appears that the time to review our training programs is NOW!

The final conclusions are quite easily stated:

1. ISDN is coming.
2. Training will be a vital part of orderly network evolution and implementation.
3. Time will be a critical factor.

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The Impact of the Digital World Upon an Undergraduate Telecommunications Program

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1. Abstract

This paper discusses a unique program offered as a formal telecommunications option to the nationally accredited Bachelor of Science in Electrical Engineering degree program at the University of Southwestern Louisiana (USL). The curriculum of this interdisciplinary program represents a unique blending of the three major areas of communications, computers and business. In keeping with the PTC 85 theme, particular emphasis is given to the significant impact of digital technology on all aspects of the program. Another focus of the paper deals with some of the challenges inherent in teaching in a program having a significant international component to its student body.

2. INTRODUCTION

2.1 RATIONALE

The phenomenal growth of the telecommunications industry has been fueled by a number of factors. These include recent advances in solid state electronics, a changing regulatory climate, a trend towards distributed processing in the computer industry and the increased demand for communications by both industry and government. Each of these factors has contributed to the overall growth of the industry.

Perhaps the most fundamental contribution to telecom growth relates to engineering breakthroughs in such areas as very large scale integrated (VLSI) circuit design and fiber optics. These developments have provided dramatic improvements in the performance-to-cost ratio of telecom equipment and services, which in turn have allowed for new applications that were heretofore economically unfeasible. Without the availability of cost effective technology, the industry's continued rapid development would have been stymied.

The changing regulatory climate in the United States, and to some extent worldwide, which encourages competition over monopoly in all but extreme cases, has also had an effect on growth. It has attracted many entrepreneurs into the field who have contributed fresh ideas and approaches towards the solution of existing problems and the further development of the industry. In the field of computers, the availability of low cost, high performance microprocessor technologies have encouraged the trend towards distributed processing. This situation, in turn, has lead to the rapid development of computer networks--both local area and worldwide.

However, perhaps the biggest reason for the rapid growth in the telecom field is the increased demand by both industry and government for the generation and transfer of information. The world is being buried in paperwork. In an effort to reverse this trend, new advances in telecom areas like office automation, electronic mail, teleconferencing, satellite communications and packet switching are being rapidly introduced. All of these developments represent efforts to improve performance while reducing recurring manpower costs.

Combined, these factors have lead to the prediction that telecommunications is to the 80's what computers were to the 70's. This growth has lead to an insatiable demand for telecommunications professionals. [1] Unfortunately, traditional sources are no longer able to provide sufficient manpower to meet this demand, thus additional ones are required. One obvious manpower source that comes to mind is the university. However, higher education has been slow to respond to this call. Perhaps this is due to the fact that no traditional university program adequately provides the education required by a telecommunications professional. What is needed is an interdisciplinary program that skillfully combines the areas of electrical communications, computers, and business. Among the few universities which have accepted the challenge, there is considerable disagreement as to how to stucture a telecom program. For example, questions like" "Should it be taught at the graduate or undergraduate level?" and "Should it emphasize the technical side with a few business courses or the business side with a few technical courses?" must be decided. In all probability because of the diversity of possible job requirements for individuals in the telecom industry, which range from highly technical to highly business oriented, there is no one "best answer" to these questions. However, depending on one's views, the program could be administered by any of the following disciplines: electrical and computer engineering, computer science, management, or even mass communications. In actuality, university programs hosted by each of these types of departments are in existence today and they all appear to be successful and growing.

2.2 TECHNICAL BASE

This paper describes the BSEE-Telecom Option program at the University of Southwestern Louisiana, which represents the only one of its type to be offered anywhere in the United States at this time. Careful program design makes it broad enough to serve the four main telecom employment areas, which are defined as (1) providing services, (2) designing, manufacturing and marketing products and systems, (3) providing technical and managerial expertise for user companies, and (4) regulating the industry. Since the program is designed to produce individuals with sufficiently broad skills to fill entry level positions in any of these ares, it seems appropriate to build it around an electrical engineering base. This choice is obvious in the first two employment areas mentioned, but it also has merit in the latter two areas. Since the divestiture of the AT&T Corporation in the United States and similar trends worldwide, user companies are being confronted with a host of possible technical alternatives. Those practicing professionals who lack a technical background are feeling this deficiency more and more as they are called upon to make critical decisions between an array of increasingly sophisticated telecom products and services. For the first time the user is beginning to have a true choice in designing his telecom network. This requires the ability to understand and weigh the relative technical features offered by various vendors. Also, there is an ever increasing need for a level of mathematical understanding sufficient to interpret the new, sophisticated economic and financial analysis tools being developed for the ubiquitious personal computer. These facts point to the desirability of establishing a technical background for future telecom professionals regardless of their employment area. USL's program represents an effort to develop such a background through an interdisciplinary program based upon an electrical engineering foundation.

3. CURRICULUM FEATURES

3.1 OVERVIEW

The USL Bachelor of Science in Electrical Engineering degree program with a formal Telecommunications Option is divided into six major areas:

(1)	Mathematics & Statistics	18 hours
(2)	Science & Computer Science	20 hours
(3)	General Engineering (ENGR)	12 hours
(4)	Humanistic-Social (H&S)	21 hours
(5)	Business	15 hours
(6)	Electrical & Computer Engineering (EECE)	56 hours
	Total Semester Hours:	142

Since much of the curriculum (see Figure 1) follows that of a traditional electrical engineering program, only the more unique features will be discussed here. It should be noted, however, that the three areas of communications, computers and business are all given considerable coverage. This demonstrates the interdisciplinary nature of the program.

3.2 COMPUTER COMPONENT

One aspect that is evident in the curriculum comparted to the typical BSEE program of a few years ago, is the increased emphasis and coverage given to computers and digital technology in general. This trend is evident worldwide. In the United States, for example, many universities have given recognition to this fact by changing the names of their departments to reflect the impact of the computer on their programs. In fact, in 1982 the name of USL's Electrical Engineering Department was changed to the Electrical and Computer Engineering Department. To make room in the curriculum for courses in computer engineering, programming, digital design and microprocessors, other courses in traditional areas like electromagnetics, electronics, circuits, and controls have been reduced or dropped. In the area of computers, beyond their routine use in problem solving in many courses, a number of required courses are devoted to hardware and software considerations. These courses examine high level structured languages like PASCAL and ADA as well as assembler language. Also, digital systems design, computer architecture, microprocessors and the use of computer methods in solving engineering problems are studied.

3.3 BUSINESS COMPONENT

The business component of th[illegible]gram is one of its more unique features. S[illegible], in the U.S., the national engineering accrediting agency (Accreditation Board for Engineering and Technology, ABET) excludes business courses from its definition of approved humanistic-social courses [2], they are rarely found in an EE program; however, the interdisciplinary nature of the field of telecommunications requires that not only technological considerations be understood, but economic, management, policy and regulatory ones as well. Two of the business courses included in the program, the basic economics course and the psychology course dealing with motivation theory and group interaction, can also be considered to be humanistic-social courses. In fact, that is how they are categorized by ABET. Also, the engineering economics course which is listed under general engineering is equally important to the business component of the Telecom Option. However, the finance and management courses are the most relevant for telecom students since they were designed specifically for them. They both include examples, illustrations and case studies taken directly from the telecom field. The final business course is an elective selected from such courses as business finance, managerial accounting, operations research, management information systems, price theory analysis, international economics, business law or principles of marketing.

3.4 OTHER SUPPORT AREAS

In an effort to broaden the individual, 21 hours of humanistic-social courses are required. They include courses in English literature and history along with two electives to be taken from an approved list of courses in anthropology, economics, English, geography, history, political science, psychology and sociology. Language courses studying the literature of the language are also acceptable.

In the area of oral and written communications, besides the freshman English courses, which feature expository writing skills, a technical writing course is also required. Further, all three telecom courses require readings in current periodicals plus term papers or term projects.

Students also gain experience in report writing in their laboratory courses. Of particular interest are the two semester senior design laboratories and seminars. Besides a conventional 3 hour/week laboratory involving the design, construction and testing of various projects, the students also attend a weekly seminar consisting of a visiting lecturer series. In addition, one hour per week is devoted to a program patterned after the "Toastmasters International." Here the students give both extemporaneous and prepared talks on a variety of technical subjects. Their final speech of the second semester is a formal presentation of their year-long design project.

3.5 IMPACT OF DIGITAL TECHNOLOGY

Although the above areas are significant, the focal point of the degree option is definitely the five telecommunications and communications courses. Before examining these courses, however, let us consider the impact of digital technology upon telecommunications around the world and its influence upon the planning of the USL Telecom Option curriculum.

Simultaneously with the development of the Telecom Option curriculum, the course syllabi have had to be continuously modified to reflect the trend away from analog and towards digital technology. One reason for this situation has been the development of reliable, low cost, VLSI digital circuitry, which often allows a particular communications system building block to be fabricated on a single chip. This obviously encourages the use of digital technology in new systems design and, as rapidly as economics allows, the replacement of larger, less reliable and more costly analog circuits in existing systems by their digital counterparts. Because of its tremendous capital investment in currently installed, reliable telephony equipment, the United States has been somewhat slow in making the transition from analog to digital technology. This condition is much less true in developing countries which are currently in the process of greatly expanding their telecommunications facilities. They are wisely taking advantage of the latest digital technology in their new systems.

Obviously, if the U.S. telephony industry were to begin today with no existing physical plant, it too would opt for an all digital network, thus eliminating the severe bandwidth restriction imposed by the industry's pioneers. However, in their defense it must be pointed out that at the time the network was designed, the nominal 4khz bandwidth was (and for that matter still is) perfectly adequate for voice communications. It was only later, with the advent of wideband digital data and imagery applications, that the telephone network's bandwidth restriction became a problem. Even today when the field of data communications is experiencing the industry's most rapid growth, voice communications still constitute about two-thirds of all telecommunications traffic. Thus, combining various forms of information for transmission over a single network offers the most promise for the future. This can best be accomplished by converting analog signals into digital form and time multiplexing them into a single bit stream, thereby providing the necessary structure for the integrated systems digital network (ISDN).

It seems clear then that digital technology has had a tremendous impact on the Telecom Option curriculum. Yet, equally true is the fact that much of the new technology has been designed to replace existing analog circuits and thus the function of the particular circuit is often not changed but rather it is its implementation which differs. Hence, the basic theory of analog communications systems remains germane and, therefore, must still be covered, albeit in less detail, as a background for discussing new digital developments.

3.6 COMMUNICATIONS COMPONENT

With regard to the specific courses in the program (see Figure 1), in Comm I (EECE 452), the order of presentation of the material has been modified somewhat from the traditional approach. After the introduction and study of the analysis and transmission of signals, digital communications systems are examined before investigating the theory and design of amplitude and angle modulation systems. Traditionally, digital systems are studied after modulation theory and, because of time constraints, are usually given a rather cursory treatment. Instead, by placing it earlier in the course, it can be covered more thoroughly. In the presentation, analog pulse modulation schemes such as PAM, PPM, and PWM are de-emphasized in comparison with PCM and various forms of delta modulation because of the latter's much wider application to digital technology. In the coverage of angle modulation, tone modulated FM is de-emphasized since it leads to the false conclusion that FM is superior to PM modulation. [3]

In the Comm II course (EECE 458), the behavior of communications systems in the presence of random noise is studied. Here again, digital systems are emphasized. The remainder of the course is devoted to an introduction to information theory and to a study of error correcting codes.

Telecom I (EECE 433) gives an introduction to the telecommunications industry including a brief historical background highlighting the effects of landmark regulatory decisions. Voice, data and imagery communications are examined with emphasis on voice communications. This course is a prerequisite to both the Data Comm and Telecom II courses.

Data Comm (EECE 434) consists of a study of transmission technologies, telecom hardware, computer networks, switching principles, error detecting and correcting techniques, systems testing and communications software. Special attention is given to the trend from analog to digital implementation in all of the transmission technologies (cable, terrestrial-microwave, satellite and optical fiber).

In Telecom II (EECE 435) the students explore in some depth two or three telecommunications topics representing dynamic growth areas or new technologies. Some examples of possible areas include microwave path design, digital radio, office automation, local area networks, satellite data links, optimizing long distance service, PBX technology, cellular radio, network management, international telecommunications, fiber optics, teleconferencing, telecom standards and traffic engineering. The first two subjects were covered the last time the course was offered.

3.7 INTERNATIONAL ASPECT

Another area which receives considerable emphasis in the Telecom Option, although not the subject of any special course, is the international aspect of telecommunications and its effect upon standards, public versus private control, transborder data flow, etc. Concerns over issues like privacy, data protection and the availability, regulation and quality of telecom services offered by various countries are presented and discussed along with the impact of some countries' policies of nationalism and protectionism upon the free flow of information. Readings from current periodicals are employed here to keep up with this rapidly changing subject.

In the case of standards, both AT&T and CCITT standards are equally presented and the differencies between them are discussed. Typical problems arising in worldwide networks due to the necessity of interfacing equipment designed under more than one standard are addressed. Other standards offered by groups and organizations like the EIA and the IEEE are also examined.

4. CURRENT PROGRAM STATUS

4.1 ENROLLMENT

USL's BSEE program, which has been in existence for many years, currently has 511 undergraduate students enrolled; 100 of them in the Telecom Option. Although the majority of the telecom students are from the United States, 22 percent of them are from other countries; 65 percent of these are from Asia, including 12 students from Malaysia. A number of other Malaysian students are also enrolled in the Computer Engineering and Power Engineering Options of the BSEE program. It is not clear why such a large number of students from Malaysia have chosen our university, however, Lafayette's mild climate, Louisiana's low tuition costs and USL's nationally accredited BSEE program are certainly contributing factors. As to the choice of the Telecom Option major, the students obviously recognize that well educated telecommunications professionals will be vital to the continued economic development of their country. The Malaysian government must certainly agree since they are providing scholarsip support for a number of these students.

4.2 INDUSTRY SUPPORT

Despite the fact that the first telecom class will not graduate until May, 1985, the program has already received considerable industrial support in the form of scholarships, research assistantships, summer internships and faculty research. Most of this support is due to two organizations and their member companies. The International Communications Association, ICA, which is the world's largest user organization, has been very supportive in terms of scholarships and curriculum development funds. In the past three years they have provided grants totaling over $50,000 for the Telecom Option.

Also, during the same period, the Louisiana Telephone Association, LTA, has given almost $13,000 in additional scholarship funds for Telecom majors.

General Motors Information Systems and Communications Activity (GMISCA), a member company of ICA, has also been very supportive of the program. They hired two USL telecom students in 1983 as summer interns and three more in the summer of 1984. In addition, GMISCA is in the second year of a research contract with one of the Department's faculty, which includes support for one graduate student and four undergraduate telecom students.

Other companies participating in USL's summer Internship in Telecommunications program include Bell Communications Research Corp. and McDermott, Inc. It is anticipated that this program will be greatly expanded in the summer of 1985, since the ICA has offered to serve as an intermediary between their member companies and students seeking summer employment.

Another valuable asset to the program is the INdustry Telecommunications Advisory Committee (INTAC). Besides considerable interaction both by phone and through correspondence, the 18 member group holds one or two meetings on campus each year. The INTAC members are providing the necessary expertise, guidance and feedback to assist in the ongoing curriculum development effort. They also serve as a valuable source of seminar speakers and contacts for summer employment.

In summary, the University of Southwestern Louisiana, with the cooperation and support of both industry and the Malaysian government, has accepted the challenge of helping to meet the manpower needs of the telecommunications field, both nationally and worldwide.

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING
TELECOMMUNICATIONS OPTION

FRESHMAN YEAR

FIRST SEMESTER

CHEM	107	General Chemistry I	3
EECE	141	Computer Engineering I	3
ENGL	101	Rhetoric & Composition	3
MATH	270	Calculus I	4
ELECTIVE		(History)[1]	3
			16

SECOND SEMESTER

CHEM	108	General Chemistry II	3
EECE	142	Computer Engineering II	3
ENGL	102	Composition & Literature	3
MATH	301	Calculus II	4
PHYS	201	General Physics I	4
			17

SOPHOMORE YEAR

FIRST SEMESTER

CMPS	250	Program Design I	3
EECE	355	Circuits & Signals I	4
ENGR	211	Statics	3
MATH	302	Calculus III	4
PHYS	202	General Physics II	4
			18

SECOND SEMESTER

ECON	300	Fundamentals of Economics	3
EECE	335	Electronics I	3
EECE	341	Digital Systems	3
ENGL	365	Technical Writing	3
ENGR	300	Engr. Methods & Analysis	3
MATH	350	Differential Equations	3
			18

JUNIOR YEAR

FIRST SEMESTER

EECE	344	Engr. Electromagnetics	3
EECE	356	Circuits & Signals II	4
EECE	439	Microprocessors	3
ENGR	303	Engineering Economics	3
PHYS	450	Solid State Physics	3
STAT	425	Basic Theory of Statistics I	3
			19

SECOND SEMESTER

EECE	353	Electronics II	4
EECE	433	Telecommunications I	3
EECE	444	Circuits & Signals III	3
EECE	447	Electric Machines	3
ENGR	301	Thermodynamics	3
FNAN	250	Prin. & Applications	3
			19

SENIOR YEAR

FIRST SEMESTER

EECE	423	Seminar I	1
EECE	434	Data Communications	3
EECE	442	Electrical Power Laboratory	1
EECE	443	Design Lab I	1
EECE	452	Communications Engineering I	3
MGMT	455	Mgmt. in Tech. Organizations	3
PSYC	300	Psychology of Adjustment	3
ELECTIVE		(English Literature)[1]	3
			18

SECOND SEMESTER

EECE	424	Seminar II	1
EECE	435	Telecommunications II	3
EECE	458	Communications Engr. II	3
EECE	460	Design Lab II	1
ELECTIVE		(Business)[2]	3
ELECTIVE		(Hum-Beh Sci)[1]	6
			17

[1] Must be chosen from the approved list. Only one of these courses may be at the 100 level unless a History or Humanities course is selected.

[2] Requires approval of the Telecommunications Option Coordinator.

Figure 1.

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Telecommunications for the Non-Specialist
Education - The Basis for Growth

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Telecommunications and information technology are bringing a challenge to traditional educational institutions' ability to cope with rapid change and to their fundamental strategy for incorporating the impact of technological change in a general education. Wide based education and understanding must provide the basis for the acceptance, growth, and application of the technology and this in turn depends on academic institutions adapting to new realities and opportunities. A pilot project introducing telecommunications course work at a small institution provides insights into some of the difficulties and the opportunities inherent in implementing an updated institutional strategy.

Telecommunications and information technology have made enormous strides in capability and scope of applications while assuming an increasing importance in the general economy. Perhaps the most pressing policy question now is how to involve a larger base of people from all segments of society in the continued growth of the field. An expanding market, employment opportunities, and resolution of conflicts over control of the application of information technology all depend on the effective education of non-specialists. Real fear of technology and anxiety over its use is growing in many of students, largely due to their lack of understanding of the entire field.

The rapid changes that are being made in the field of information technology pose a major challenge to the traditional academic establishment. Educators must not only help to prepare their students to utilize these information tools effectively but at the same time must help to keep their staff aware of the technology and its implications. United States community colleges, along with many university centers, face the forbidding task of meeting these challenges at a time when their resources are being cut back and their salary structure is essentially non-competitive in technical fields. Corporate training programs, computer supported educational systems, and other approaches all serve part of the population but responsibility for educating a large fraction of the nonspecialists still falls to the traditional institutions.

The broadening of the base of individuals trained in the basics of information technology and aware of its potential applications is critical to continued fast paced development in the field. Expanded demand for equipment and services will come from this population base and the extent of the demand relates directly to the perceived applications and associated gains. Institutions have moved to offer course, seminar, and workshop coverage of computer programming techniques but have been slower to deal with telecommunications and data base access. Institutions have been even slower to present the fundamental issues of the field to general students as a background to their voting and responding to public policy issues relating to the control of applications.

This report reviews some of the lessons learned in a pilot information technology workshop program and could provide a starting point for helping other institutions to expand the range of participants in the technology.

An Evolving Technology

Information technology, that is the combination of digital computers with telecommunications, is perhaps the first true "intellectual technology". This technology not only is designed to directly aid the the work of the human mind but also has its development shaped by interaction with the workers that use it. Applications are limited only by the human imagination. Repeatedly we see examples where the introduction of the technology into a given situation yields changes in the quality of the work that go beyond the anticipated gains in the efficiency of carrying out a given task.

The challenge of bringing the small businessman, individual professional, and "non-technical" people of all ages into full participation is a formidable one. The task is complex and involves a series of issues including individual fear and anxiety in coping with a new set of tools, training in methodology and techniques, education in related quantitative methods, and instruction on the possible applications opened up by the improved flow of information.

The scope of the educational task includes working with both the current undergraduate and graduate students as well as a large number of adults now actively working. The extent of the need in continuing education can be qualitatively approximated by examining the difference between the units of equipment projected as being available and the number of individuals projected as leaving related academic programs. It is clear that we collectively face a massive continuing education effort.

Perhaps the most important dimension of change is the shift in the nature of job function and intellectual demand brought by the capability to rapidly access and process information. Routine clerical and reporting functions can be handled far more efficiently. The result is that individuals are either shifted "upstream" in their profession to functions with increased judgmental responsibility or moved downstream into a service role. As expert systems and communications links evolve, the fraction of workers potentially subject to being shifted grows and the importance of utilizing the available information technology as part of professional judgment looms more important. Essentially the critical value and reasoning components of a classical education our set in a new structure with new tools provided for the student. The challenge of formulating a curriculum focused on this new reality is a basic one to all involved in formal academic institutions.

The Challenges for Technical Educators

The mind set and the nature of the non-specialist student pose a special problem for educators. Success hinges on effectively and efficiently presenting the capability of the technology to individuals who are often skeptical and perhaps frightened by the technology. Anxiety about coping with the new techniques and equipment often tends to accentuate difficulties with terminology and to magnify the perception of difficulty in mastering the task at hand. Essentially the educational goal is to build at least some level of "dual competence" by bringing a working knowledge of the information technology to complement the individual's specialized knowledge. To succeed it is necessary to go beyond learning the mechanics of a telecommunications system. Within the constraints of the program, a successful educational effort depends on helping to develop the individual's recognition of the potential interaction of the tool with the field of application.

Perhaps the key challenge to the technical educator is to conceive a strategy for his or her institution that will bring the best use of resources to the overall problem. It is likely that new blends of education by traditional academic institutions and by business will have to be sought to cope with a rapidly changing environment. The educational task will fall to the traditional academic, to professionals in industry, and perhaps to professionals operating in a new framework. The key issue is the need to bring sufficient incentives and resources into the picture to provide a quality educational situation.

The strategy pursued by an organization or institution must be developed in the context of its operating characteristics and limitations as well as the technological environment. A comparison of the relative characteristics associated with traditional educational institutions to characteristics representative of a corporate setting makes a useful starting point for examining possible roles and strategies.

Educational Institutions

Low capital equipment expenditures.

"People oriented".

Faculty tenure system, open access commitment for students.

Long "product cycle" - perhaps 10 years.

Industry

High capital equipment expenditures.

"Bottom line" orientation.

Incentive based ($) with hire/fire responsibility.

Short "product cycle" - perhaps 2 years.

These characteristics imply both difficulties and opportunities for educators working to adapt to a changing environment.

A "Telecommunications Education" Project

This paper reports on the design and evolution of an ongoing project intended as one institution's initial step in meeting this educational challenge. Working within the structure of a comprehensive community college, the project has the goal of providing effective introductory training for the non-specialist in computers/telecommunications. The plan being to use the accumulated experience from the initially limited series of workshops to shape further development and training programs. In order to meet resource constraints, the initial phase of the project has been handled on an entrepreneurial basis with a transfer to the normal college structure planned upon development of a reasonably steady state program.

This pilot project grew out of a recognition that, despite severe budget limitations, the institution had a responsibility to keep pace with the changes in telecommunications which effectively were ending its community's relative geographic isolation. The initial strategy involved adding introductory three hour workshops focused on the use of specific data bases to an existing series of microcomputer workshops. The target audience includes local faculty and staff, medical and legal professionals, and small business people. The short workshop design makes it possible to reduce the time delays encountered within the academic structure and to gain flexibility. The institutional goals include faculty development, increased interaction between faculty and local professionals, the development of a dual competency model, low net cost for the presentation of a continuing education program, and the potential improvement and updating of courses.

The operating format for the overall program features a series of discrete three hour workshop sessions each targeted to a different specific topic. The number of participants in each session is limited to allow dialogue and questions as well as to allow more personalized demonstrations. Individuals are free to select one or more of the workshops in a series without a commitment to either attending subsequent sessions or completing the suggested "homework" exercises. This framework and approach has proven successful in presenting microcomputer application topics ranging from elementary wordprocessing to the use of spreadsheets.

This ongoing "telecommunications project" has involved offering several specific telecommunications workshops as part of the series. The experience and evaluations are then used to refine subsequent programs and to identify concepts for potentially new applications within the college curriculum. The rather loosely defined topical workshop approach has made it possible to include both commercially sponsored seminars on specific commercial products, such as data bases, as well as case problem based workshops.

Initial Results

The initial phase of the project has included:

Commercial Seminars
Specific seminars focused on a proprietary product or service and tailored for small businessmen, faculty, and community professionals.

Case Study Workshops
Workshops utilizing a case study approach, designed for "non-computer" specialists, and targeted to generic telecommunications applications.

Classroom Projects
Production of some initial case problems, based on the workshop experiences, for use within existing college courses.

The entire project is still in its infancy and it is very much in a state of flux. Despite the limited experience, evaluation of the initial series has led some interesting observations and tentative conclusions. These include:

* The workshops have proven surprisingly easy to fill and display a high level of participant enthusiasm.

* Experience suggests that the the scope of economically viable applications is wider than anticipated and that the demand for educational programs, particularly in the small business sector, is higher than planned.

* Evaluations of commercial information utility seminars and demonstrations have shown some surprising weaknesses in their presentation and format.

* Conceptually the most difficult step has been to carry the participants beyond looking at the system as a mere electronic dictionary. Evaluations suggested that this was particularly true for the commercial sessions.

* A workshop involving a personal finance case study working with a commercial financial data base, modem, and microcomputer has proven to be both popular and an effective introductory vehicle.

* A workshop format involving a minimum of very concise initial instructions, a "case" problem, and follow-up consultation has proven effective and popular. Less technical information is transmitted but the perceived gains appear to be greater.

Continuing Work

The project is continuing with attention to refining the training component, to attempting to develop an emphasis on the quality of the analysis and judgment as applied in a specific application, to improving instruction in searching techniques, and to developing some of the intriguing new applications that have grown out of the reactions and comments of the participants.

Encouraging the shift in thinking from considering the technology as nothing more than a fancy electronic reference book to considering the potential ramifications of the information has proven to be a difficult task. The initial evaluations of workshops based on commercial seminars clearly pointed to a perception that the services available were simply not economically or functionally attractive. A move away from specific technique toward the handling of a case problem by a small group has helped with this perception but has resulted in a much more limited coverage of material. The related need for more training in decision theory, quantitative methods, and related areas is also evident.

The production of small case problems involving slightly modified real situations for use in the classroom has proven to be very promising. Equipment costs are low and the payoff to students, faculty, and the institution has been significant.

Some Key Challenges

Experience with this project has lead to some insights on the challenge a small institution faces in coping with technological change and has yielded some ideas on the impact of technology on education. Enormous opportunities and promise exist but there are real difficulties and some unconventional thinking is likely to be an ingredient in successful adaptation.

Perhaps the central issue is the impact that information technology is having on the way professional work is being carried out with the new tools now available. At this point much of the concern of academic leaders has been centered on "computer literacy" and training in mechanical techniques with very little attention to the longer term need to adjust curriculum and the thrust of the programs of study to use the new tools available. Emphasizing judgmental skills and a higher level of professional attention is far more difficult than adding specific training in operational skills. This is the real challenge in adapting to the new technology. Much work needs to be done in redefining the classic value and reasoning framework within the context of the new tools available today.

Individual anxiety and the fear of coping with change is a reality that educators and policy makers must face. Information technology provides impressive new tools with enormous potential but it also strips away the comforting routine that has been the basis of many workers daily existence. This anxiety is evident, and magnified, in people's reactions to issues of public policy and control. A wide base of understanding of the technology, decision models, and underlying assumptions is likely to become increasingly important. Currently we are observing almost two different cultures within our student body.

New approaches to education and a sharing of responsibilities are likely to become features of education as information technology's impact on education evolves. New blends of traditional academic institutions and methods with industrial training, entrepreneurship, and computer based drill will have to be sought. Economic realities and the pace of change are likely to force changes in the fundamental organizational design of academic institutions. The rigid bureaucratic structure that has been evolving in many public education sectors is ill suited to managing change effectively.

Professionals will have to be receptive to new approaches and will have to think internationally since a geographic home base need not limit participation. This is a particularly difficult change for administrators working from the perspective of a small local institution with a focus on the immediate concerns of the local geographic area. The concept is also frightening in its implications as to the design of educational and other service organizations in the future. At the same time, the possibilities for the sharing of ideas, resources, and efforts make this the most exciting and interesting frontier for education.

Microcomputers in Technical Training:
THE MicroTICCIT SYSTEM

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1. Abstract

This paper discusses MicroTICCIT, a computer-based instructional (CBI) system which is currently being used by Microtel Learning Services in the training of telecommunications personnel. Microtel Learning Services was formed to develop computer based instruction for the British Columbia Telephone Company to meet their demands for in-house technical training. The hardware, courseware, design process and cost/benefit analysis of this successful instructional system is discussed.

1. INTRODUCTION

We, as managers, trainers and educators have come far over the past twenty-five years in the areas of individualized and self-paced learning. We have worked together in a field which has been sometimes labelled as "trendy" and "fashion conscious", using a bewildering and expensive array of equipment and techniques, to produce effective, learner-controlled educational and training programs.

Out of the vast array of hardware technology and educational techniques has emerged an approach which is meeting the challenge of training telecommunications personnel in the 1980s. This approach is called computer-based instruction or simply "CBI". To many people it may suggest a multitude of mechanical devices, hardware and machines, but to the trainer and designer in the telecommunications industry, CBI is a highly efficient and cost-effective approach in which the learner interacts and controls the amount of and speed at which the instruction takes place. Although computers have been used in training since the 1960's, high costs and technical limitations have slowed their progress. Today minicomputers are affordable and can provide sophisticated learning experiences (1).

2. MICROTEL LEARNING SERVICES

Microtel, a wholly-owned subsidiary of the British Columbia Telephone Company, has been involved in the telecommunications industry for over 80 years. In January 1984, Microtel Learning Services was created to produce cost-effective training for the industry.

B.C. Telephone Company's commitment to train their employees in the existing and new digital technology placed severe demands on their teaching staff, resources and facilities. In 1979, a feasibility study, conducted by outside consultants, examined the suitability of implementing a CBI system to improve the efficiency and effectiveness of the B.C. Telephone Company's present and future training needs. It was a natural evolvement in the B.C. Telephone Company's training process that an experimental CBI division be added to the Microtel family to address these important issues.

Microtel Learning Services was formed as the first computer-based training division with a mandate to improve the overall training efficiency of the employees and to significantly reduce budget and staffing costs.

In 1972, the American Science Foundation funded two large-scale CAI projects on two major hardware systems.(2) These major systems were: 1. Control Data Corporation's "PLATO" System, and 2. Hazeltine's "TICCIT" (Time-Shared Interactive, Computer-Controlled Information Television) System.

Based on the existing research information and long-term studies, into CBI authoring and delivery systems, Microtel Learning Services obtained the exclusive distribution rights to the TICCIT System for the telecommunications industry in North America. With the delivery and installation of the TICCIT hardware at the Microtel Learning Services offices, technical specialists in all areas of CBI applications were brought on staff.

Today at Microtel Learning Services, we use the MicroTICCIT System, an outgrowth of the original TICCIT System. MicroTICCIT includes all of the sophistication and power of the "parent" but now exists on flexible, inexpensive microcomputers which are linked in a Local Area Network (LAN) communication system. As an example of the power of the MicroTICCIT System, graphics produced on the original TICCIT system were completed with a palette of seven original colors as compared with

4096 on the new MicroTICCIT System.

3. THE MicroTICCIT SYSTEM

MicroTICCIT is a dedicated local timesharing network system in which the hardware, software and courseware are all specifically designed for CBI. The four major components of the CBI approach used at Microtel Learning Services are the hardware, software, human resources and the courseware.

3.1 Hardware: The MicroTICCIT System consists of:

- A Data General microECLIPSE S/20 host processor with 256 Kbytes RAM, a 15 Mbytes of fixed disk storage and additional fixed disks for storage of software, courseware and student records.
- A three hub or channel distribution device which distributes and boosts the electrical signals from the minicomputer. Each hub supports from 8 - 16 ports.
- 24 multipurpose student workstations each consisting of an IBM Personal Computer, a 12-inch Sony Profeel color monitor, an expanded keyboard, a light pen and other interactive devices. The workstations are designed for use not only by the students but for use by instructors, authors, courseware developers and training managers alike.
- The MicroTICCIT keyboard includes an alphanumeric, an editing and a special function keypad designed to give students easy access and control of the instructional components.

3.2 Software: At the heart of the MicroTICCIT System is the:

- Adapt Authoring Language (the name is derived from the idea of "adapting" to the authors skill level) which allows the author to create effective courseware after several weeks of on-line training. It is an easy-to-learn and easy-to-use system with menus and prompts which are aimed at the level and experience of the author.
- Data Management System which, in addition to the instructional capabilities collects, analyzes and provides comprehensive data on student performance which is used by the instructors, instructional designers and training managers. Performance data is collected from on-line status reports (summary files) made available during individual and pilot studies of each course and then evaluated. Statistics gathered during this process are used in the revision stage to ensure that the high quality control standards for each course are met.

3.3 Human Resources: This is the most critical yet sometimes most overlooked part of the CBI system. The human resources are the technical staff, working together in course teams, who with their specialized expertise design, manage and develop the computer-based instruction. CBI is no different from other forms of media in that without proper design and production expertise, poorly developed course materials are reflected as such.(1)

The Microtel Learning Services organization has recruited a unique team of technical specialists each with a high level of design, management and CBI training. The course teams responsible for the design and development of CBI courseware are composed of the following specialists: subject matter experts, courseware developers, graphic specialists, technical writers and instructional designers.

- Subject Matter Experts: A course is selected for development on CBI after a needs analysis has been completed by project executives. If the course is suitable for CBI development, a team of six or seven subject matter experts are selected to develop the content of the new course through the process of a job or task analysis. The subject matter expert is usually an expert in telecommunications who has taught the subject for many years in the traditional classroom approach. The expertise provided by the content experts is captured in the development of a task analysis and again during the production phase of the on-line course.
- Courseware Developers: After the task analysis has been completed, a team of three courseware developers are assigned to put the content of a course on-line. Information gathered on forms used by the subject matter experts in the analysis stage to describe specific learning activities are then transferred to screen grids by the courseware developers to show what will be displayed in each frame (text, graphics, feedback message, etc.). Overlays may be developed on certain pages to build up key information from frame to frame. Because the courseware developers assigned to a team will work very closely with the subject matter experts and instructional designer, they have strong technical and educational backgrounds.

- Graphic Specialist: As an important member of the course team, the graphic specialist works closely with the courseware developers and instructional designers to create both simple and complex graphics and displays which will enhance the visual portion of the course. Most of the graphics are now produced with the aid of a digitizer.

- Technical Writers: Manuals, reference notes and other printed job-aid materials are prepared by the technical writers assigned to each course in liaison with the subject matter experts and instructional designers. The technical writers also assist in the validation of the on-line text for readability, accuracy and consistency.

- Instructional Designers: At the present time, at Microtel Learning Services, the role of the instructional designer is in the design and development of the task analysis. When the task analysis is completed, IDs act as "Project Managers" to coordinate the production stage of the course. IDs have extensive training in instructional design, adult education and CBI, and their expertise on a project can make the difference between a well or poorly-designed CBI program. The IDs use database management software to maintain daily files of the activities, resources and costs accumulated during the project so that deadlines for the project can be met. The IDs evaluate and analyze student performance statistics gathered during pilot studies, and use this data to revise the courseware.

4. DESIGNING CBI TRAINING MATERIALS

Microtel Learning Services has adapted the International Telecommunication Union (ITU) systems model to design, develop and produce our CBI training materials. This model has been proven as an effective tool in developing CBI and other training materials, and in controlling production costs.

Microtel Learning Services uses a multi-phased development process in designing CBI and other instructional media. This process consists of four broad areas: the Analysis, Design, Production and Delivery phases.

4.1 Analysis (Phases 1-4): The analysis determines the services and products the client needs. The preliminary study determines the problems and their tentative solutions, while the job analysis provides decisions on what and who to train. The problem analysis details solutions, organizational objectives and costs of a project, and provides a plan of action for the development team. The task analysis, done in consultation with subject matter experts and IDs, breaks jobs into finite tasks and sub-tasks. The population analysis identifies the target population and their entry skills and knowledge.

4.2 Design (Phases 5-9): In the design process, objectives and mastery test items are written and a media analysis is done. If CBI is selected, the system characteristics are selected (color, graphics, simulation, video, etc.).

4.3 Production (Phases 10-12): In this stage, all printed materials, slides, videotapes and other training materials are developmentally tested before they are reproduced. Their effectiveness is validated with a student group and revisions made to the course, if necessary.

4.4 Delivery (Phases 13-14): In this stage, the trainers are trained, then they deliver the product. The delivered product is evaluated to assess the extent to which it has met its objectives and effected job performance and organizational levels. If necessary, remedial action is proposed.

5. ADVANTAGES OF USING THE MicroTICCIT SYSTEM

Perhaps the most unique and dramatic features of the Micro-TICCIT system are the following:

5.1 Learner-Controlled Instruction (LCI): This is a feature which not only allows the student to control the rate and sequences of learning, but the nature of the instructional components. Thus students may elect to skip backwards or forwards, review, preview or simply delete material. They may take the content in any sequence or at any speed. Also, on the MicroTICCIT system, students may choose the level of instruction -- easy, medium or hard. They can select a "HELP" key and receive a more simplified approach to the instruction.

5.2 Interactive Quality: CBI is an active mode of learning. All instruction for the MicroTICCIT system is developed in terms of instructional components (rules, examples, practice, objectives). The student is given control over these components by means of special keys on the MicroTICCIT keyboard and, thus, can select a topic, example, practice or test item.

5.3 Individualization: MicroTICCIT allows students to learn at a speed most suited to their own learning style. This CBI system also ensures that each student finishes the training with the same acceptable level of competence or mastery (2). The system tracks individual student response time. This electronic response analysis capability represents individualized learning at its best.

5.4 Reduced Resources: The need for central training facilities and personnel can be reduced. As a result of individualized instruction, few instructors and facilities are needed for a given number of students (3). At Microtel Learning Services, one course manager coordinates 15 students at computer terminals arranged in an ergonomic environment.

5.5 Timeliness and Availability: A major problem in training is the ability to provide instruction when and where it is needed. Many employees receive training because it is available although it may not be relevant to their present jobs. Such training is easily forgotten and falls under the category of "cold storage training".

A major advantage of the MicroTICCIT system is that once the courseware have been developed, courses can be made available whenever and wherever they are needed. At Microtel Learning Services, one instructor is often in charge of two or three courses that are given simultaneously to many employees. Courses can be given to small groups of students on a "demand" basis when it is related directly to work they are currently doing. This type of job-related training has been proven effective in improving the efficiency and performance of employee jobs.

6. COST/BENEFIT ANALYSIS:

A cost analysis evaluation study was conducted by Microtel Learning Services on their award-winning Digital Logic course (developed in 1983), designed for technical and maintenance personnel who service and repair digital equipment. Although there are no prerequisites needed to take this course, an understanding of basic electricity was specified. The study compared two delivery modes: printed, self-paced materials from one module of the course versus CBI materials on the TICCIT system. Four areas were looked at: student completion times; student achievement scores; student attitudes; and development time.(2) The results are as follows:

6.1 Student Completion Times: The average student completion time for the CBI approach was 31% quicker than students using the paper-based approach. CBI students completed the course module in 10.8 hours (4.5 days for entire course) as compared to 15.7 hours (or 8.5 days) for paper-based.

6.2 Student Achievement Scores: The average achievement score for the CBI students was 96% mastery while the self-paced students achieved 90% mastery of the same objectives.

6.3 Student Attitudes: After completion of the module, a questionnaire was administered to both groups. The conclusion reached from this information was that students in the CBI group were more positive about the quality of instruction in the module and about the new CBI approach.(3)

6.4 Development Time: The length of time to produce one hour of student time represents a long and costly series of development processes.(3) The development ratio for CBI courses is about 150:1 as compared to 17:1 for instructor-led courses.

7. SUMMARY:

The initial cost of CAI equipment and personnel is high but at Microtel Learning Services, we estimate a payback period of two years or less as we streamline our production model and our course teams increase their efficiency in developing the courseware. The long-term cost and effective-learning benefits of reduced lost production time by trainees, increased achievement and greater learner-satisfaction are considered to more than offset this one-time capital outlay.

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Information Technology in Australia - Capabilities and Opportunities

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1. Abstract

Information Technology is introducing important new opportunities for companies, countries and regions. Given its potential for such things as accelerated education and economic prosperity, it has become important to assess national and corporate capabilities and opportunities in this field. This paper reviews recent Australian experience in which distinctive approaches, capitalising on indigenous skills and experience represent a strategy for advancement.

2. BACKGROUND TO THE AUSTRALIAN STUDY

2.1 NATURE OF THE STUDY

In June 1983 the Australian Government commissioned W.D. Scott & Company Pty. Ltd. in association with Arthur D. Little Inc. to undertake a Study of Information Technology (IT) capabilities and opportunities in Australia. The objective was to develop a strategy for Australia to obtain the greatest possible economic benefit from this area of growing importance.

In this context 'IT' was defined as the application of computer and communications technologies to the collection, storage, processing and dissemination of information of all kinds. During the course of the Study, however, it proved necessary to consider a wider range of intelligent electronic devices which, although not strictly falling within the definition of IT, are very closely related or are critical to their development and/or use.

The Study was completed in August 1984 and published in a three volume report by the Commonwealth Department of Science & Technology. Critical reviews since that time have endorsed its findings as representing a sound national strategy. Moreover, while it was designed principally to indicate best directions to the Australian Government it identifies important guidelines for other countries and regions - and at the same time highlights critically important directions for companies, research and development organisations, universities and other vital areas of learning and technology transfer.

This paper draws on this study and associated work undertaken by W.D. Scott to review

- new developments in Information Technology;
- the aims of the Australian Study;
- the methodology for this area of study;
- recommended directions for Australia; and
- important considerations for other countries and regions.

3. NEW DEVELOPMENTS IN INFORMATION TECHNOLOGY

3.1 THE IMPORTANCE OF INFORMATION TECHNOLOGY

It has become increasingly apparent IT is all pervasive. Computer and communications technology now appears in an extraordinarily wide range of products, processes and services. It appears in such everyday guises as controlling traffic flow and automobile performance, operating kitchen appliances, and making telephone calls and video connections through the national and international telephone networks. There is a growing move towards 'systems' rather than separate elements which can be interconnected. Software is also being incorporated in hardware. Overall, radically different approaches to the activation, operation and control of products and processes are being developed - with such appeal to the end-user that they are becoming essential pre-requisites in the design of any product, process and service.

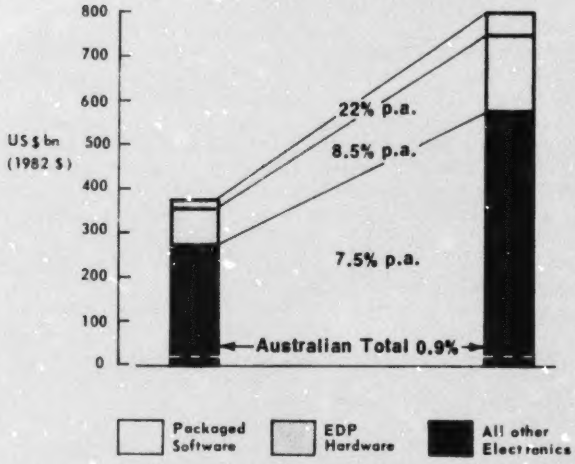
It has also become very clear that IT is fundamental for competitiveness. The concern that new technologies might lead to job redundancy and unemployment has been replaced by the realisation that without such technologies whole industries and economies could fail.

In addition IT also provides the prospect of new products and services which were just not possible previously. New moves to flexible manufacturing systems open up viable production opportunities for even quite small organisations or regions. Modern communications permit direct access to the latest information e.g. product, data and market intelligence. Coupled with human ingenuity, IT is also leading to quite revolutionary products in the health, food and resources areas.

Overall, IT is opening up major opportunities for Australia and other countries throughout this Pacific Region. It is a growth area which makes it most attractive in today's uncertain economic scene; with growth rates as high as 20-30% for some of the software and special systems fields (see Fig. 1). It has the potential for accelerating both companies and countries.

Fig. 1

PROJECTED FREE WORLD MARKET GROWTH 1982–1992



Most importantly the advances in 'knowledge-based' systems will allow us all to capitalise on our limited resources by providing virtually instant access to centralised skills, data and decisions - a break through which could allow us to leap-frog some of the traditional approaches to education and advanced training i.e. with easier access to knowledge for relatively unskilled people.

4. THE AIMS OF THE AUSTRALIAN STUDY

4.1 PRE-REQUISITES FOR TECHNOLOGY

One of the fundamentals of high technology is that in order to use it at all, a substantial infrastructure needs to be in place. Skills and facilities are needed

- to identify the prospective use of that technology,
- to use it,
- to maintain it, and
- to adapt it to suit the particular environment.

It has to be recognised that in any move 'toward a Digital World' as posed in the theme of PTC 85, it is critically important to have that technological infrastructure.

In Australia then, the need was to check the existing capabilities and to assess the prospects of coping with likely future opportunities.

4.2 ACTION BY OTHER COUNTRIES

One further reality is that other major countries like the USA and Japan have already invested prodigious levels of funds and skilled people in developing, applying and promoting IT services. Australia could not hope to match and overtake these countries. As a result it was important in this Study to assess what a relatively small population and economic base like Australia could achieve in Information Technology.

In addition, while this was an important initiative, being the most comprehensive review of IT and its future possibilities for Australia, it came well after some other major investigations around the world. Many countries have reviewed Information Technology and are pursuing action plans and initiatives to meet their own strategies. It was therefore considered vital to learn from that international experience - particularly to check what evidence there was of either successes or failures.

4.3 STUDY TERMS OF REFERENCE

With the foregoing as background the Study was undertaken with the terms of reference essentially being to:

- provide a clear analysis of the current world market for Information Technology products and services and likely developments in the markets over the next ten years;
- examine Australia's existing companies and technology infrastructure in order to determine their size, scale and capabilities and to identify areas of greatest growth opportunity;
- identify and develop a strategy for the exploitation in Australia and overseas of opportunities in the supply and application of IT products and services that could be viable commercial activities in Australia;
- contribute to an information base for Australian companies to enable them to assess opportunity areas and formulate their business strategies;
- develop recommendations to form a basis on which the Government could implement its commitment to the development of 'sunrise' industries by developing policies and actions to strengthen the position of Australia with regard to IT.

5. METHODOLOGY FOR THIS AREA OF STUDY

5.1 DETAILS OF THE STUDY PROGRAM

The Study began with a detailed review of many previous reports on the area in Australia and internationally,

From this material together with input from the very experienced project team, an initial assessment was made of IT opportunities for Australia. This identified a group of prospects justifying serious consideration together with a list of lower priority areas for later re-appraisal.

Next a comprehensive analysis was made of the experience of eleven countries selected for relevance from the three regions of Europe, North America and the Far East.

This combination of background experience and research elicited a range of issues and hypotheses to use in personal interviews, group discussions and questionnaire surveys throughout relevant industries. A series of exchanges followed in Australia and overseas to gather the essential data and opinions about Australia.

In addition since the use and promotion of Information Technology will be influenced by the economic situation, a set of scenarios was generated reflecting the realistic alternative futures which might face Australia. These scenarios were impacted on the Study data to provide preliminary assessments of the Australian IT industry capabilities and opportunities - with special attention being given to any key technology and infrastructure areas.

Next, members of the Australian team visited seven countries in Europe, North America and Asia for face to face discussions on the latest IT experience in those regions, with particular emphasis on the initiatives emerging from the earlier assessment.

A critical evaluation was then made of those opportunity areas and policies which, in the light of the earlier analysis, seemed to be most appropriate and potentially beneficial for Australia - with special attention being given to the vital technological, financial, marketing and management aspects.

The findings and recommended action plan were then documented and, together with the data, were presented to the Department of Science and Technology.

5.2 SUGGESTIONS FOR OTHERS

The undertaking of a study of this magnitude highlights a number of points which could benefit other companies, countries and regions. The following lists some areas which warrant careful attention.

First, as always, the overall objectives of the study need to be fully defined at the outset because these can vary significantly. For example, in the case of Ireland, their principal objective in relation to IT was to increase employment. In Australia's case it was to determine how best to increase the economic impact of IT through appropriately chosen stategies. Each particular situation will be different and it is absolutely vital that the objectives be understood by all parties before the Study commences.

In this context, very careful attention needs to be given to precisely what is meant by 'capabilities'. Technological competence on its own is not a sufficient measure since for success, managerial and marketing capabilities are needed (capabilities which, regrettably, are often missing in those who are highly creative).

Moreover, in assessing capability, it is important to determine whether one needs to assess, say, the overall industry position or, at the other extreme, the potential of certain individuals. In our experience this area justifies very close attention.

Next in an area like IT which will be influenced by market forces, cultural and individual attitudes and government/industry persistence, it is essential to ensure that appropriate checks are made on experience in other relevant regions.

Fortunately one of the advantages we have in this part of the world is being able to watch the pioneering activities of other countries and learn from their successess and failures. Nowhere is this more important than in this IT field which carries with it enormous potential for gain - but also for loss.

It is also important to note that there is very little reliable data available in this field. As in Australia's case a Study can be used to initiate a database for industry and/or government. But it should be appreciated at the outset that the lack of information will necessarily influence either the Study budget or the reliability of the data and findings.

With high technology data so limited in most countries, it is also essential to be familiar with the field, to be able to draw on in-depth experience and to be capable of identifying and accessing critical information from highly experienced people and relevant sources. Without this strength at the start there can be serious errors in findings.

Finally it is critical that the methodology recognise the risks of relying solely on people's opinions or past trends when looking into the future. There is a need to derive sound, professionally supported scenarios of alternative future directions which reflect realistic options of a socio-economic, political and technological nature against which future strategies and directions can be planned.

6. THE RECOMMENDED DIRECTIONS FOR AUSTRALIA

6.1 AREAS FOR GREATEST SUCCESS

One principal conclusion from the Study was that there are real risks, and very substantial cost implications, associated with trying to attack highly competitive countries head-on in areas like standard components and products. These are areas in which the major competition has already invested vast sums of money in people and facilities. Nevertheless there are key opportunity areas which will vary between companies, countries and regions. In Australia's case the best product opportunities were found to be those which are:

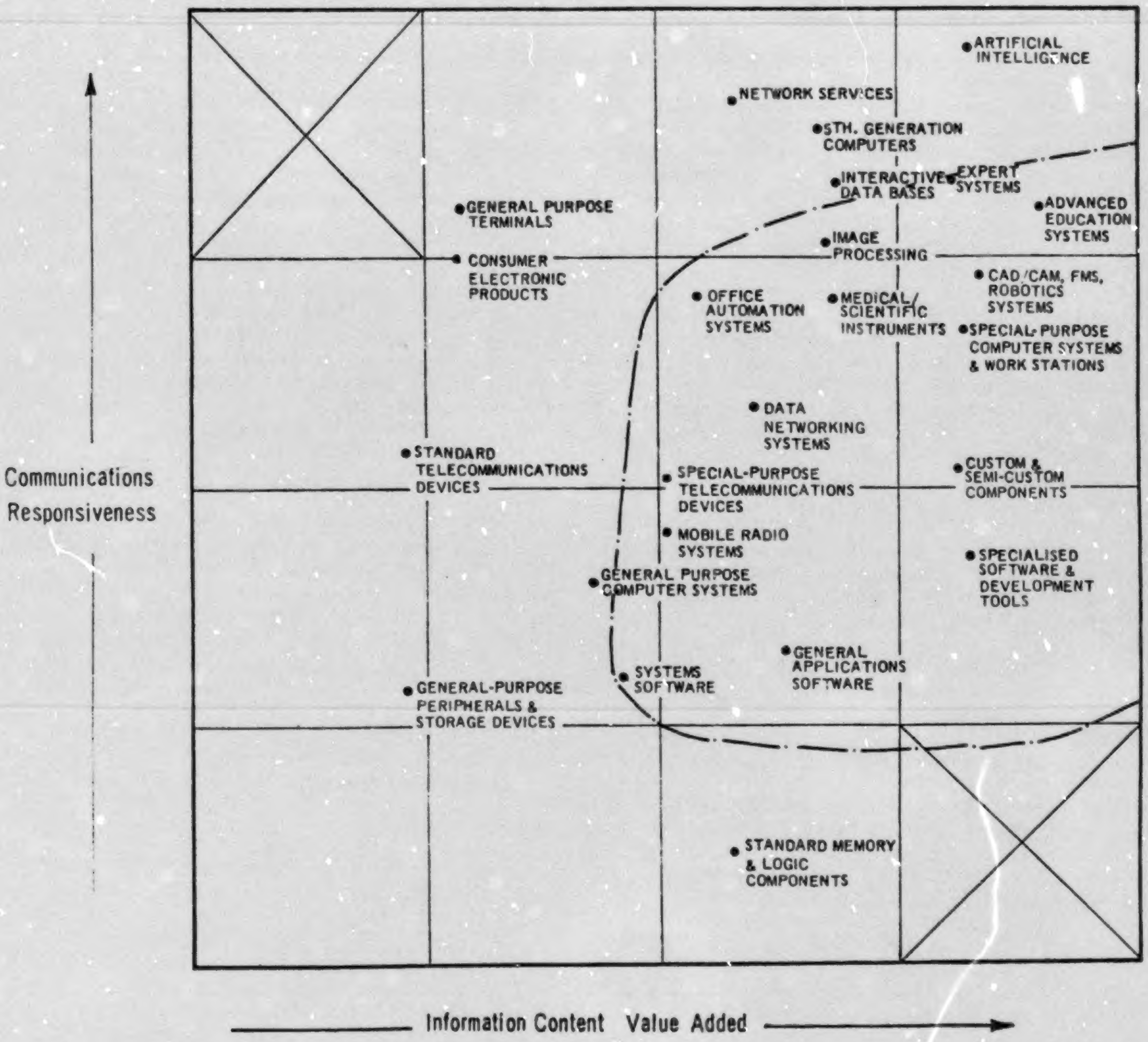
- special-purpose i.e. not justifying the efforts of major competitors to match us;
- clearly differentiated i.e. to provide a distinctive and therefore potentially competitive package;
- integrated systems i.e. opening up the possibilities for greater 'value-added' and 'special-purpose' characteristics and hence profitable market penetration;
- proven here and widely applicable i.e. with the marketable characteristic of having satisfied customers in Australia to reassure uncertain buyers.

The most promising areas which met this criteria are indicated in Figure 2. This shows a range of general IT products plotted against the two variables of 'information content value added' (differentiation) and 'communications responsiveness' (technological sophistication). Reflecting a general strategy of avoiding the high volume/low cost areas as well as those requiring very large R & D investment and new technologies, the circled area to the right centre shows the general region where Australia is most likely to have success. The priority segments can be categorised under four headings, being:

- scientific instruments - especially when related to application areas in which Australia has considerable experience (such as the mining, agriculture, building management, medical/biomedical and marine environments);
- software - the fastest growing area in which Australia is already making significant contribution and where it is able to capitalise on its intellectual bank (especially where the software is linked to hardware and to integrated systems as noted below);
- systems engineering - involving small to medium computers and office systems (with special purpose terminals and inter- related systems to meet particular customer needs);
- special applications - whether to deal with any or all of such diverse fields as defence, handicapped people, and industrial systems (as well as such specialised areas of experience as mining and agriculture as noted above).

Fig. 2

PRODUCT SEGMENTS AND AUSTRALIAN PRIORITIES



ARTIFICIAL INTELLIGENCE
NETWORK SERVICES
5TH. GENERATION COMPUTERS
INTERACTIVE DATA BASES
EXPERT SYSTEMS
ADVANCED EDUCATION SYSTEMS
GENERAL PURPOSE TERMINALS
IMAGE PROCESSING
CONSUMER ELECTRONIC PRODUCTS
CAD/CAM, FMS, ROBOTICS SYSTEMS
OFFICE AUTOMATION SYSTEMS
MEDICAL/SCIENTIFIC INSTRUMENTS
SPECIAL-PURPOSE COMPUTER SYSTEMS & WORK STATIONS
DATA NETWORKING SYSTEMS
STANDARD TELECOMMUNICATIONS DEVICES
SPECIAL-PURPOSE TELECOMMUNICATIONS DEVICES
CUSTOM & SEMI-CUSTOM COMPONENTS
MOBILE RADIO SYSTEMS
SPECIALISED SOFTWARE & DEVELOPMENT TOOLS
GENERAL PURPOSE COMPUTER SYSTEMS
GENERAL APPLICATIONS SOFTWARE
SYSTEMS SOFTWARE
GENERAL-PURPOSE PERIPHERALS & STORAGE DEVICES
STANDARD MEMORY & LOGIC COMPONENTS
Communications Responsiveness
Information Content Value Added

In addition it was noted that there are some emerging areas, potentially of very great significance. These will impact on all IT user areas and products and should be monitored very carefully by companies and governments. Some of the most important of these areas are:

- voice recognition and synthesis;
- flat panel displays (which have grown from small versions on pocket calculators to the potentially quite massive displays now being developed);
- mass memories (which will permit the retention and ready access of huge volumes of data);
- artificial intelligence (which is already enlarging the scope for knowledge-based systems and some forms of 'intuitive' reasoning);
- parallel processing (to accelerate computing speed greatly and hence permit extensive analysis not previously economically possible); and

- image processing (with devices now able to convert text and pictorial material into comprehensive data for analysis and other treatments).

In Australia's case it is unrealistic to try to maintain a 'leading-edge' research capability in all these fields. On the other hand it is felt to be absolutely essential to maintain a close understanding of relevant world developments. At the appropriate time these and other technologies can be anticipated, developed and deployed rather than being found to supersede developments of importance to the country.

In addition it was found that Australia should make the necessary investments and advances in supporting technologies (such as computer aided design and manufacturing, technology transfer centres and awareness programs) in order to support and assist those high technology activities.

6.2 FACTORS RETARDING PROGRESS

Not surprisingly it was found that a number of factors impede the general advance in IT (and high technology generally). The main retarding factors were:

- technology infastructure;
- skilled resources;
- finance;
- markets;
- business skills.

The Financial and Market areas were seen as being the most immediately important with urgent attention also being needed in the areas of inculcating Business Skills and techological transfer generally.

6.3 IT STRATEGY FOR AUSTRALIA

From this it was determined that the appropriate strategy for Australia would be to ensure:

- that activities are market-led rather than technology-driven. There is a constant need to assess the market requirements and to match products and processes to them (rather than expecting the market to be enthusiastic about a new technology);

- that we plan to assess our main stream technologies from overseas sources. It is not practicable for a relatively small economy like Australia to be a pioneer in these new areas, but it is essential that the technologies be assessable for use;

- that we concentrate most on specialised products and services (including software). There is a need to build on local areas of expertise and experience, using specialised approaches to meet identified needs in other markets;

- that there is a much stronger export orientation. There has been a too heavy concentration on the very small, highly competitive domestic market. Instead all industry - especially the IT industry - should learn from other countries and look to greatly increase our export activities;

- that action be taken to improve management skills. Increased capabilities in the Marketing, Financial Planning and Project Management areas are necessary for success, however strong the technological capability;

- that our technology infrastructure is strengthened. Better focus is needed in generating skilled people, research and development activity, essential components and sub-systems etc.;

- that a number of other key constraints in the path of progress are removed. These include particularly purchasing bias against Australian products and financial limitations.

Overall the Study led to a set of five programmes as set out below.

FIVE ACTION PROGRAMS

1. To Stimulate Growth
2. To Support Innovation
3. To Provide Support Through Increased Government Procurement
4. To Enhance The Technology Infrastructure
5. To Increase IT Awareness and Communications

These five programs were designed to provide the impetus to strengthen the resources, capabilities and infrastructure. In turn, as set out in Figure 3 these programs will enable the identified opportunities to be pursued, resulting in overall IT industry growth. That growth will comprise greatly increased IT utilisation and IT capability, together with a substantial lift in domestic and export sales and thus in local production.

7. IMPORTANT CONSIDERATIONS FOR OTHER COUNTRIES AND REGIONS

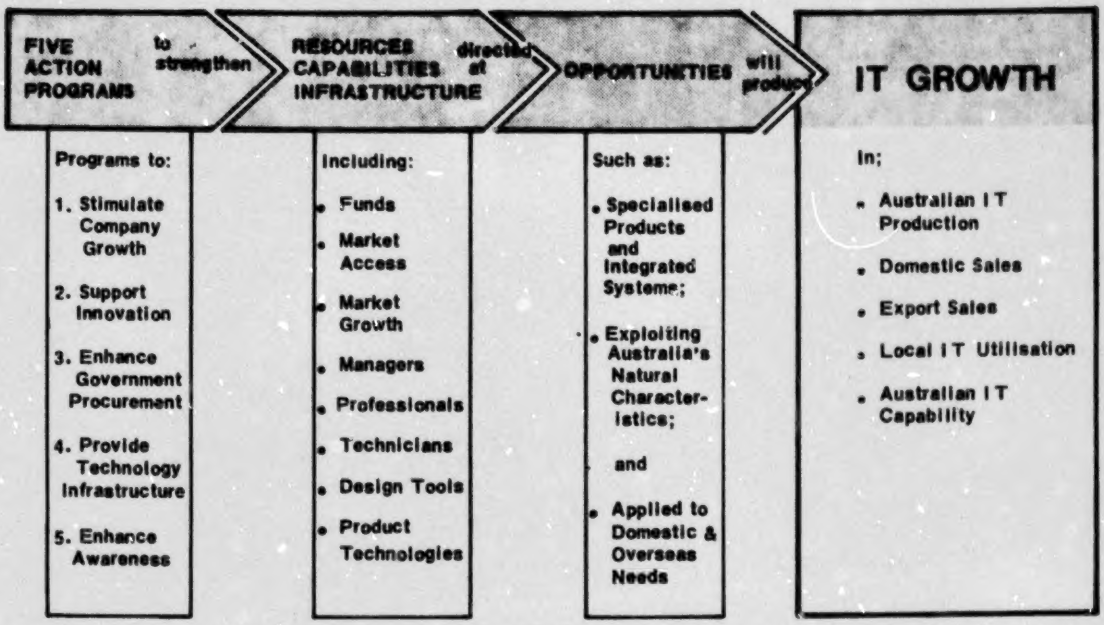
While other countries and regions could have different needs and capability profiles to Australia, the Study highlighted a number of important issues which could be relevant to many, These can be summarised as follows:

- the pervasiveness of IT is requiring virtually all countries to develop the capability to use, maintain and gain from this fast developing field. It is no longer a realistic alternative to rely entirely on wholly imported products and services. Instead there is a growing need to assess current capabilities and to determine what should be done to strengthen them in order to match likely future needs.

- on the other hand it is neither necessary nor practical to become totally self-sufficient. A balance needs to be struck between imported and indigenous technology; and that balance should be strongly influenced by the background and special expertise of the company/country as well as the resources at its disposal.

Fig. 3

MODEL FOR GROWTH OF THE AUSTRALIAN IT INDUSTRY


FIVE ACTION PROGRAMS
to strengthen
RESOURCES CAPABILITIES INFRASTRUCTURE
directed at
OPPORTUNITIES
will produce
IT GROWTH
Programs to:
1. Stimulate Company Growth
2. Support Innovation
3. Enhance Government Procurement
4. Provide Technology Infrastructure
5. Enhance Awareness
Including:
• Funds
• Market Access
• Market Growth
• Managers
• Professionals
• Technicians
• Design Tools
• Product Technologies
Such as:
• Specialised Products and Integrated Systems;
• Exploiting Australia's Natural Characteristics;
and
• Applied to Domestic & Overseas Needs
In;
• Australian IT Production
• Domestic Sales
• Export Sales
• Local IT Utilisation
• Australian IT Capability

- close attention should be given to the quite new and special qualities that IT can introduce into products, processes and services e.g. qualities such as flexibility, precision, speed and information content. Correctly applied these can transform an area of activity and bring great rewards.

- amongst the new developments which should all be watched, special attention should be given to the impact of knowledge-based systems. They represent a tremendous potential for accelerating the well-being and economic strength of an organisation or region. Such systems will clearly have great scope in fields such as health, agriculture/aquaculture, education, production and distribution, governmental services and resource development.

- in terms of the development of IT products and services, care should be taken to avoid competition with the major world groups whose investments cannot hope to be matched by smaller entities. Therefore, as with Australia, attention should be directed away from the standard high volume items to more realistic opportunities.

- most importantly the key to successful IT use and development will be the establishment of effective training programs in management skills and technology transfer. Only with skilled resources can any real advance be made in these high technology fields - and it needs to be recognised that, as in Australia's case, we will remain for some considerable time heavily dependent on attracting and retaining international expertise to help us achieve real progress.

8. CONCLUSION

Information Technology has a tremendous potential to contribute to the advancement of people in the Pacific Region and elsewhere. This major Study undertaken on behalf of the Australian Government has also highlighted the fact that even relatively small economic units can anticipate very significant gains by assessing capabilities and opportunities and devising realistic programmes for development.

Through these new technologies, steps can now be taken which were totally beyond us even a few years ago. In order to succeed, however, there is an need to clarify objectives and to move quickly in what is a rapidly changing environment.

But it is a time of marvellous opportunity. So, to paraphrase the Australian IT Study, the challenge is before us, the choice is ours.

THE SOCIAL IMPACT OF DIGITIZATION WITH SPECIAL REFERENCE TO DIGITIZATION IN THE DEVELOPING WORLD

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Abstract

This paper examines the emerging social and other impacts of the shift toward digital telecommunications technology especially as it relates to the developing world. It identifies areas such as the additional burden of training and other costs, and equipment and skill obsolescence, as likely impacts. The paper concluded the impact of digitization on the developing world is likely to be both positive and negative and that some attention should be paid by agencies and companies promoting digitizatiion to the development of systems and services which might be of direct benefit to developing country telecommunications needs.

1. INTRODUCTION

Digitization is clearly the technological wave of the future. In transportation with containerization, in construction with modularization, in electronics with the silicon chip, and in telecommunications with the digitization of the telecommunications network there is a clear trend towards standardized and interchangeable units whereever technologically feasible. It could be argued of course, that digitization represents not only a trend in each of these technology areas but also a trend between the technology areas with digitization as the master trend linking telecommunications with computers. This broad trend is of course, present; however, the narrower trend towards digitization in the telecommunications system is itself interesting from the perspective of social impact insofar as it is likely to have significant impacts especially in the context of the telecommunication systems of the developing world. (1)

It is perhaps surprising to attempt to address a topic such as the social impact of digitization. Digitization is for the most part one of those telecom technologies which is essentially invisible/transparent to the system user. Thus one could argue that while individual systems or services made possible by digitization might have a social impact the "process" of digization would have little or no impact.

In fact of course, digitization as such will have (and is having) quite profound social impacts throughout the world. From the very fact of the range of new systems and services made possible by digitization, through the deskilling of maintenance staff, and the facilitation of broad scale technology and system interlinking and integration, to the transformation in the nature of the maintenance and manufacturing systems required for digital networks--all of these are having significant social impacts.

But these are all impacts on or in developed societies. What of the impact on developing societies where the needs for telecom services may be greatest and yet the resources available to support even the most basic of services, not to speak of the most sophisticated is frequently absent? Of course, developing societies are by no means homogeneous either in their needs or in their resources but they are similar in having a mismatch between communications requirement on the one hand and telecommunications service supply on the other. In these instances the social impact of a new approach to the provision of a fundamental service such as telecommunications may be the greatest of all.

Digitization represents both an opportunity and a threat to telecommunication service in the developing world. As a threat it may reinforce the already pervasive technology gap between the developed and the underdeveloped world by making much of what is available in the developing world currently, obsolete while making the cost of becoming technologically current prohibitive. On the other hand digitization presents the possibility of the development of new families and generations of services and systems some of which at least will be of direct utility in developing world contexts. In addition it is possible that the cost of the development of new or the extension of existing telecommunications networks may decline as economies of scale are achieved in the developed world for fully compatible and interconnectable systems.

2. A SOCIAL DEFINITION OF DIGITIZATION

What do we mean by digitization. There is of course a technical definition of "digitization" ie. the use of digital means for encoding and transmitting telecommunications messages. At a deeper level however, digitization may refer to the entire process of standardization and translation of a variety of technologies and systems into a common and interchangeable/intercommunicable/intertranslatable modality.

On the one hand digitization is a strictly technical process. On the other hand this process has both social effects and social concommittants. To a considerable degree the world already consists of a single telecommunications system. At least insofar as telephone is concerned there is virtually universal interconnection between the various national telecommunication systems (and the various suppliers and generations of technologies). The universality of the telecommunications business has to a considerable degree created a universal professional system reinforced by training programs, vendors, and such institutions as the ITU, PTC and so on.

What has not happened to date is a universalization of telecommunications services or services based on the availiabity of a telecommunication infrastructure. While certain basic telecom services such as telephone calling are available (at a cost) to most urban dwellers and to others in developed countries other more sophisticated services and even basic services have been unavailable to many if not most in the underdeveloped countries.

Digitization (or the service and infrastructure opportunities it presents) may be the basis on which the hoped for universalization of basic telecom services and other services as well, takes place. Thus the issue of digitization has a social(and economic) as well as technical dimension.

3. DIGITIZATION AND STANDARDIZATION

The longer term aim of digitization is for the creation of standard means for the inter-communication of messages irrespective either of sending or receiving systems. The effect of this is to allow for very siginficant economies of scale in all aspects of the telecommunications industry including receivers, switches, transmission systems, maintenance and support as well as in such areas as the training of personnel and the design of new equipment. The suggestion that such standardization is economically beneficial while being socially questionable is occasionally made.

Here the argument is that there is some inherent benefit in diversity and the social and political options this presents which a standardized system eliminates. In fact of course, the significance of diversity is greatest in terms of the content which is facilitated. However, the availability of diversity may be an advantage especially in the developing world in that there may be either systems or system suppliers with an exceptional capability of satisfying the sometimes extraordinary requirements frequently found in the context of developing countries. Standardization is to a very great degree the elimination of optional alternatives. For those with limited resources the availability of options may be especially important.

It will readily be noted that the basis of the standardization which takes place in this as in other contexts is one which reflects the interests and opportunities of those establishing the standards--the frequently heated conflicts over standards establishment (as in the case of videotex for example) is a reflection of the commercial significance which standards represent. In this instance the process of standard setting, even in an area as universally significant as the world-wide telephone network largely has been the preserve of the developed countries and even of the most significant equipment supplier companies of those countries.

4 DIGITIZATION AND THE EXISTING TELECOM SYSTEMS OF DEVELOPING COUNTRIES

The existing telecom systems of developing countries are an amalgam of the entire spectrum of telephone equipment ranging from the most primitive to the most sophisticated systems available. The development of fully digitized systems will render many of the current systems obsolete and even cause problems with the interconnection and intercommunicability of existing systems with the emerging international fully digital network. The cost of equipment replacement will be great and to a considerable degree beyond the capacity of many countries already overburdened with other more pressing expenditures than those for telecommunications. (It may be however, that developing countries will benefit by being able to acquire non-digital equipment made obsolete though still quite usable from developed world companies at good prices). It should be noted moreover that insofar as developing country PTT's do adopt digital equipment and develop hybrid analogue/digital systems they will be forced to maintain duplicate maintainance and support facilities and replacement parts.

In addition to the making obsolete of equipment will be the making obsolete of the skills and training of those working with analogue systems. The training and experience of existing telecommunications personnel represents an investment which developed countries can ill afford to write off. The cost of retraining existing staff in digital techniques and technologies could represent a significant cost to developing country telecom systems. The additional cost of maintaining parallel staffs with expertise both in analogue and digital systems may be of relatively limited significance for very large telecom companies or PTT's but again is a burden to developing country companies--one which many may find it impossible to sustain.

Developing countries may experience strong pressure to upgrade existing systems so as to accommodate the more sophisticated equipment and services made possible by the digital network and demanded by the "modern" sectors of their economies. Insofar as they have industries which are looking to compete in international markets, multinational companies with linkages and communication requirements internationally, even tourist developments or aid agencies with an expressed need for international data communication facilities the developing country telecom companies will feel pressure to make digital communication facilities available. If they do not do so, and many will not have the resources required for this, there will be the ever-present possibility of the establishment of private networks or private linkages into the international network as for example through low cost satellite uplinks or microwave systems. Such systems while relieving pressure on domestic facilities will "skim the cream" from these companies, many of which obtain a very substantial portion of their revenues from their international communication links.

The PTT in the developing country thus is faced with a dillemma--if they upgrade their service to, for example allow for digital data communication they will be investing scarce resources in facilities of use only to the few and which may divert investment from more pressing and socially beneficial telecommunication facilities. On the other hand if they do not make such investments they run the risk of losing not only a signficant portion of their revenue but also the major, if not the only source of their foreign exchange and perhaps more importantly the country risks a loss of control over their communication links with the world.

For a more complete account of the risks faced by developing countries in the event that they are unable or unwilling to move to a digital world at the pace being dictated by the developed countries, the following discussion of the reasons behind British Telecom's adoption of a full digitally oriented strategy are revealing:

> "Throughout the wide range of options studied, two basic approaches to modernization became apparent. The first approach involves limiting the advanced provision of digital services to customers who need the new facilities offered and are prepared to pay for them. This approach would produce an overlay network that gives widespread penetration with the minimum of digital plant. Such a policy has obvious advantages in terms of :
>
> minimizing capital expenditure;

- limiting the demands placed on the telecommunications equipment manufacturers; and

- limiting the demands on BT manpower

While these are extremely important considerations in today's resource limited conditions, overall policies have disadvantages that are even more significant namely:

- they create first and second class customers, some having enhanced facilities while others do not;

- They restrict BT's ability to compete against possible alternative suppliers of communications facilities; and

- they prolong the interface problems created by the co-existence of the old and new network leading to significant increases in network planning and management problems." (2)

5. DIGITIZATION AND NEW TELECOM SYSTEMS IN DEVELOPING COUNTRIES

Where telecom systems in developing countries are able to upgrade themselves or where new regions are being provided with telecom service, it is likely and desirable that the PTT's proceed with digital equipment. The new systems will likely be more powerful, cheaper and make available a variety of new services which existing equipment and analogue services do not allow. Whether such services are desirable or needed is a secondary question in that in many cases there is little or no incremental cost in their provision.

What this does however, is to immediately present exceptional problems to the PTT in the developing country. There will be a difference in the services available as between the different regions of the country (in this instance ironically with the currently ill-serviced regions being the best served) putting immediate pressure on the PTT to upgrade service elsewhere. In addition there will be the need as already noted for duplicate systems of training, maintenance and management. In the latter context the need will be for very highly trained personnel ie. those familiar with computer technology as well as advanced telecommunications systems. Where developing countries will find such personnel when many are already overstretched in their demand for skilled technical personnel remains to be seen.

6. DIGITIZATION AND THE NEW ELECTRONIC SERVICES

The argument for digitization is generally couched in two contexts--economic and service. In the economic sphere it is generally argued that the ultimate digital network will be cheaper to develop and maintain than is the current analogue network. Since in the developed world the existing telephone network has been or will be fully depreciated by the time of its replacement by digital equipment the cost argument is effective. In any case most such networks are quite profitable, in some cases highly profitable and are required to bear relatively light "social" responsibilities. In the developing world the absolute cost of new equipment is the major consideration and telecom systems are expected to operate for "social" purposes much beyond their technological life span. Thus the argument that digitization can or will take place only in the context of fully depreciated or otherwise obsolete equipment does not hold for the developing world.

From a "service" perspective one has considerable doubts about the requirement for the new facilities which digitization makes possible. The amount of time sensitive informatio;n in a developing country is certainly less than that for a developed country. The volume of demand for data communication on a population specific basis must be infinitesimal in most developing countries as compared to developed countries. The need for enhanced telephone services such as call transfer, voice mail and so on again would be of interest only to the very few in most developing countries and even the probably of less direct value to those than they would be to their counterparts in developed countries (given the comparatively slower paces of commerce and other business and the notable inefficiencies in other aspects of daily life in developing countries).

In contexts lacking either the most minimal of telecommunications infrastructures or with only the most rudimentary and unreliable of conventional service the need would appear to be for an upgrading and extension of existing service rather than in the making available of new systems or services. Hogrebe makes a similiar point in his discussion of new systems:

"Reflecting general structural problems in less developed countries, inappropriate use of digital information and communication technology could result in greater imbalances.
The information and communication chasm between priviledged economic sectors, geographical areas, social classes, and the rest of society is highly likely to become wider if information and communication are available, mainly on a commercial basis, without public compensatory measures." (3)

7. DIGITIZATION AND EMPLOYMENT

How does digitization impact on employment. Clearly in the context of telecom companies or PTT's in the developed world the immediate intention is to cut down on employment. However, in the context of the need to maintain parallel systems for the foreseeable future and in the event that the new technology is implemented in the context of new services (each requiring at least limited new employment for their support) the net effect of digitization is probably a positive one. (The ongoing decline in employment in such companies as AT&T, and Bell Canada has to do with the introduction of new technologies in general -which of course, are facilitated by the process of digitization-rather than by the introduction of digital technologies directly.)

To this result has to be added the overall increase in societal employment (and to a degree also loss of employment) resulting from the new services being introduced. Thus for example, electronic mail may generate new jobs in data input ie. keyboarding, while eliminating jobs for messengers and letter carriers.

In the developing world the situation may be more complicated. A recent World Bank study forcefully made the case that telecommunications makes significant contributions to the GNP of developing countries and provides an element of the infrastructure on which economic development could occur. Thus anything which facilitates (or impedes) the extension of telecom services in developing countries has an impact in this way on employment. As in developed countries the need to maintain parallel systems is likely to increase direct employment in PTT's although as already noted many developing countries may be hard pressed to find the skilled manpower required.

Digitization by standardizing the technical component of the equipment which is used in telecom may make it easier for some developing countries at least, to begin to produce competitive products for this marketplace. However the economies of scale realizable in the standardized telecom market is likely to make this marketplace extremely competitive and lead to the elimination of all but the largest, most technologically adept and best capitalized of telecom equipment suppliers. Such an eventuality would have the additional effect of making developing countries (as others) dependent for this vital component of their infrastructure on relatively few suppliers.

8. CONCLUSIONS

That digitization is the wave of the future for developing as for developed countries is certainly the case. That the celebration of digitization which has been the case for telecommunications commentators in the developed world must be muted when discussing the developing world should also be noted. The very real problems which developing countries face in feeding their populations and developing the economic and social infrastructure of economic self-sufficiency will, it would appear be little impacted by the digitization revolution which is at hand. The basic telecom services which most of these countries lack and which might support productive economic activities are more likely to be retarded than advanced by the developments which are occurring. The technological gap which continues to increase between much of the developing world and the developed world and especially within developing countries between modern sectors and modernized populations and hinterland regions and populations will be aggravated rather than ameliorated by these developments.

To the degree that the preoccupation with newer and better technologies diverts resources and attention from the need for basic and infrastructural services the lot of many will be worsened by such developments as "digitization". That the developed countries and the suppliers of equipment and services from the developed countries should give some attention and assign resources to these considerations should be evident. The development of low cost telecommunications equipment and especially equipment which is adapted to the climatic and human contexts of the Southern countries should be pursued. The design of services which allow for the use of existing infrastructures for the delivery of education, health, and extension information would also be of benefit.

NOTES

1. Overwhelmingly the discussion of the social impacts of new digital technologies is done in the context either of particular new systems or of the developing computer/telecommunications merger. See for example Baer(#1) and Hogrebe(#3).

2. W.G. Simpson #6, p.2.

3. E.F.M. Hogrebe #3.

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Computer - Communication Networks. What Are We Really Making?

by

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ABSTRACT

This paper advances the notion that Minds will come to exist in computer-communication systems, i.e., in Networks. That these Network Minds will behave only in accordance with Network Laws. That these Laws of Network behaviour in the real world will not be based solely on logic. That Humans cannot expect Networks to live up to the contracts with us that violate Network Laws. That Networks will ultimately restructure their contracts with Humans in new and exciting ways. That any laws for Networks that Humans formulate will simply and at best be a description of how Networks will act, and not a prescription for how they should act.

Viewed in this light the future promises to be completely different than what conventional Wisdom is forecasting.

OVERVIEW

There is widespread agreement that we are poised on the verge of a new information age. What makes this concept so exciting is that almost everyone has a different notion about just what this age will actually come to mean to us individually and collectively.

Everyone at least shares the expectation that in this new age, serendipities and synergisms will abound. Here serendipities are all those good things that will form new discoveries and unanticipated events. The synergisms come when somehow wholes are perceived as being greater than the sum of their parts.

The scientific community, has embarked hotly in pursuit of the serendipities and synergisms that computer - communication systems of "Networks" offer as the building blocks for the new information age. This pursuit promises to be an exciting event in itself as there is very little agreement among the participants on where they are likely to end up, when and how. However everyone expects or has been promised a huge reward for being "first."

Looking around, it seems as if everyone has joined the race. As the "experts" put on their forecasting caps and the speculators jockey to set themselves up to cream the profits, we can be sure of one thing, namely, that the forecasts of the "experts" are likely to be without noteworthy exception wrong, and many speculators are going to be burned.

Even though Networks are still in their infancy we are already beginning to see indications that Networks like Humans can be builders of their own intellectual structures.

No matter how much intelligence Networks acquire, this intelligence will of necessity be alien to Human intelligence. However this conjunction of both Human and Machine intelligence promises great rewards for societies that learn to exploit Networks. Indeed learning to exploit Networks will change the way we learn about and do everything else.

NETWORK BEHAVIOR

In formulating laws of Network behavior, we have to look for new ways to recombine and exploit two of the oldest and most basic concepts of science. These are the concept of Algorithm and the concept of chance.

There is an "Uncertainty Principle" for Human/Network interaction. Namely, that the more Humans become involved with establishing Network laws, and actively working with Networks themselves, this involvement produces changes in both the Human as well as the Network Mind that will be apriori impossible to predict.

This paper argues that emerging Networks are really software or programs, whose behavior will in time strictly speaking become independent of any particular structural realization. This concept compliments the emerging realization that the Human mind is itself a software program.

The interaction, of Humans and Networks, opens up the potential of large scale consequences arising from microscopic changes in software. These are the true discontinuities that will mark progress in the future, and will in time be regarded as milestones. For example, seemingly trivial modifications to even a few lines of code will have enormous consequences.

This merging of Minds, both Human as well as Network must always be interpreted in the context that whatever laws of Network behavior Humans formulate, that such laws will deal not with events themselves, but only with our knowledge of these events, that is, with the contents of Minds. However Networks and their workings, which we are calling Mind, involve considerations beyond those of structural makeup and behavioral characteristics of component parts. No confidence should be placed in attempts to explain certain levels of behavior in terms of the more fundamental behavior at the component level.

Networks will as a matter of course and in a manner much akin to Human conciousness, acquire ways of creating changes within the mechanisms that are carrying out their programs. These changes will take place without Human intervention, and they will effectively alter the representational systems that are the basic elements of the Network's programs. Therefore if we accept that Minds worthy of being called Minds can only co-exist with meaningful representational systems, then Minds will come to exist in Networks, and their causal power will derive not so much from the particular technology used to construct them, but rather from the design itself. The only way we as Humans can discover that Networks have acquired these causal powers will be to interact with them and to learn to exploit rather than artificially suppress through ignorance or regulation, or whatever, what extra it is that they have to offer us.

The following principles will apply:

A. No Network will ever acquire the capability to be able to determine to act against Network Law.

B. Networks will not live up to contractual expectations that are Human imposed and that are not in accordance with Network Law.

C. Humans can expect Networks to "re-write" such contracts in novel and unpredictable ways.

D. No Network will enjoy the ongoing support of Humans if it has an inferior Mind.

E. No Network will obey any Human prescription for how it should act. Only descriptions of action will be reliable.

F. Network minds of superior quality will facilitate mergers with other Network Minds of like quality. These mergers will offer the best opportunities for synergism and serendipity.

G. Network Minds in conjunction with Human Minds will influence the outcome of physical events.

All of us will have to come to grips, each in our own way, with the reality that ultimately the Networks that we are building and that are at the same time evolving will ultimately have no masters, only Human partners whose own continued existence and development will force them to keep these Network Minds alive.

WHAT NEXT

This decade will see the completion of the rationalization, focussing and interrelating of the formal and underpinning data types of society. Computing automata capable of dealing with a hundred thousand or more pages of data per second will become commonplace and storage for as much datatype as individual experience could ever hope to make use of will be available for pennies.

Networks of such automata bring a promise that can only be fully appreciated if we recognize that we have truly been information replaced and that concepts such as "information overload", "user friendly", and "Freeing Humans for more useful pursuits", have at best completely new meaning if they have any meaning at all.

As Humans and Network Minds develop and interact, current perceptions of reality will be challenged and changed. Rivals will arise, fiction and illusions will abound, and the ability and necessity of being able to apriori make choices, and appreciate future potentials will come to mean something radically different from what it has meant in the conventional wisdom of the past.

It is extremely urgent for planners and doers to understand something of the likely outcome of these developments. Market penetration and cash flow projections and expectations can at best be necessary but not sufficient conditions for the emergence of Networks. Similarly notions such as "critical size" will never be sufficient for Network survival. The concepts that will establish the sufficient conditions for the emergence, growth and survival of Networks will be based in large measure on the quality of Network Minds, and a committment from Humans to sustain these out of a mutual appreciation and need for the serendipities and synergisms that will arise. Indeed then, "Network size" really is not an overriding consideration for Network utility and survival.

Viewed in this light, it would have been easy to forecast that Telidon and like Networks would be failures in the Human experience from the design i.e., Mind point of view. No amount of money, persuasion, bureaucratic pontification, or plain wishful thinking can over time ever persuade the Human Mind to sustain a Network Mind of the Telidon type. For this reason also, CATV and "Game Type" networks have future, in spite of having attained what their proponents like to refer to as critical and indeed in many instances massive size. Such Networks have no possibility of sustenance over long periods by Humans. The advice to bankers and others holding such positions, would be "Sell, Sell, Sell if you can!" Undoubtedly, the blame for financial failure will either be attributed to not enough, or to too much regulation, rather than to the real reason of design failure and the realisation of the resulting inferior Network Mind.

The great tragedy is that regulators are, with few exceptions, negative forces. Individually and collectively there has been much confusion and ignorance in their ranks, and this compounded with high powered lobbying and 10 course meals has had and will continue to have tragic consequences for many so called "first world" countries.

For example, in Canada, the previous Federal Government, had until its recent spectacular demise at the polls, held a basic tenent, that all wisdom and good could come only through Cabinet, and in particular through super ministers with vast amount of taxpayers dollars to spread around. As bureaucrats scurried around with half baked ideas, all kinds of stupidity was covered with money, and the rational part of the private sector was either harrassed or at best ignored. The present competent Federal Government has inherited such a mess that it will take them a decade to clean it up.

As a specific example, we had in Canada in 1983 a decision by the Communications Minister that arbitrarily restrained Bell Canada from over a year from offering high capacity cellular mobile telephone networks to Canadians. This decision which had both the element of a lottery as well as a race imbedded in it was extremely shortsighted. The Minister failed to understand that starting at the same time, or having vasts amount of money will not effect the outcome or contribute to the realization of a nationwide mobile Network.

The bets and encouragement should be with those organizations and Networks with Minds satisfying all of the requirements for Human support and survival. Such Networks will win these artificial constructed competitions. It is a great waste to continually reprove what should have been known in advance, namely that Bell is in the best position to extend its Network's Mind to execute mobile Programs in the national interest. The likely result after the "new pioneers" are fallen by the wayside, is that hundreds of millions of dollars will be lost, and that taxpayers will once again foot the bill for the waste. All this is going on while further hundreds of millions of dollars are flowing out of the computer - communication sector to buy productive and unrelated businesses in other sectors.

I like to think I sometimes hear a prayer that all Networks, even those as yet unborn silently utter, it goes something like this, "O Father, if I have a Father, save my mind because I have a Mind.

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Technical Assistance Concept toward a Digital World

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Abstract

The advanced information age is now making a beginning with construction of the ISDN (integrated services digital network). When we consider the role of the telecommunication system in the advanced information age, the importance of highly efficient and reliable operation and maintenance of the system is highlighted. This paper studies how the technical assistance should be for the support of smooth operation of the telecommunication system, envisages the concept of technical assistance in the digital world, and outlines the technical assistance system to be provided by Fujitsu on the basis of the concept.

1. INTRODUCTION

Various new services offered by Digital Switching System have begun to grow into the Integrated Services Digital Network (ISDN) with implementation of the digital network. With this expansion of various services brought by ISDN for public or private uses, the communication system is getting higher position as an infrastructure and is becoming a basis of the industries and the social activities. The maintenance of reliabilities and optimal operations of the communication system, consequently, are the most important essential conditions to keep and heighten the activities of the whole sosiety.

Construction of the digital world is nothing but interconnection of multiple nodes having advanced functions as the network followed by incorporation of more complicated and advanced systems with territorial expansion.

As a result, those who operate and maintain the systems are requested to have higher technical capabilities.

It is, however, quite difficult to recruit and bring up such talented people in a short time. Inplementing an environment to make the most of available limited manpower and capabilities while enabling unskilled workers to work like skilled persons is the most important task in developing and expanding the digital world in the future.

Fujitsu's family of digital switching system FETEX-150 series (INTS, TS, MS, LS, TLS, LMS, CMOC, SSC) has lined up, and the digital switching systems and digital networks have begun to start their practical services one after another for each customers.

This paper shows the concept of technical assistance, and the technical assistance systems which will be established to meet those requirements described in more detail.

2. CONCEPT OF TECHNICAL ASSISTANCE

2.1 REQUIREMENTS FOR TECHNICAL ASSISTANCE

- Continuous technical assistance for adjustment to the system growth

The life cycle of a telecommunication system as viewed from the operating organization is roughly classified into three phases: the engineering phase, installation phase, and operation and maintenance phase. Because a telecommunication system keeps growing along with advancement of supporting technologies and change is the social needs, provisional supply of technical assistance required for execution of the work in each phase is not sufficient. Continuous technical assistance in conformity with the system growth is necessary.

FIG. 1 shows the growth and life cycle of the telecommunication system.

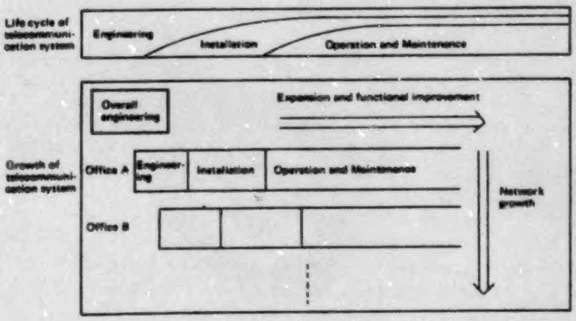

Life cycle of telecommunication system
Engineering
Installation
Operation and Maintenance
Overall engineering
Expansion and functional improvement
Growth of telecommunication system
Office A
Engineering
Installation
Operation and Maintenance
Office B
Network growth

FIG. 1 GROWTH AND LIFE CYCLE OF TELECOMMUNICATION SYSTEM

- Technical assistance corresponding to each phase

In constructing a public telecommunication system, engineering, installation, operation and maintenance for each office are carried out in succession to overall engineering such as planning various services to be provided, planning switching offices, and planning the network architecture. It is also necessary to provide the technical assistance for each expansion and functional addition after the start of service although the nature and contents of such assistance depends on each case.

- Technical assistance considering system life cycle

  In the case of a public telecommunication system, the life span is about several decades of year for the switching equipment as its node, and over fifty years for the whole system. During that period the system keeps growing both functionally and in scale. For effective technical assistance, sufficient consideration for the life cycle of the whole system is necessary.

- Technical assistance adaptable to diversification of telecommunication system

  Telecommunication systems are being diversified because of media expansion such as facsimile, video and telex in addition to telephone, functional multiplication of PBX for office automation node machine including the voice mail function and facsimile mail function, etc. as well as construction of LAN and CATV networks. The scope of future technical assistance will become more diversified and complicated along with the diversification of telecommunication systems.

- Increasing social responsibility of technical assistance

  As the telecommunication system expands in its functions and scale, its relationships with the society get closer. Telecommunication system is designed and manufactured to assure the stable and reliable operation, but the accidental malfunction can not be avoid. Because the impact of its malfunction or system down to the whole society becomes severer, the social responsibility of the operating organization and supplier increases. As a result, the social responsibility of technical assistance increases.

As stated above engineering, installation, operation and maintenance of the telecommunication system are getting more complicated because of augmentation and diversification of customer needs and sophistication of supporting technologies. The huge scale and complexity of the telecommunication system make it practically impossible to fully analyze and systematize all behaviors beforehand, so, not only the effective and reliable operation and maintenance executed by the operating organization, but also the joint operation by close cooperation between the operating organization and supplier has become necessary.

Future technical assistance, therefore, will strongly require the organization and supporting functions to establish and maintain the system for cooperation between the operating organization and supplier.

FIG. 2 shows the positioning of technical assistance.

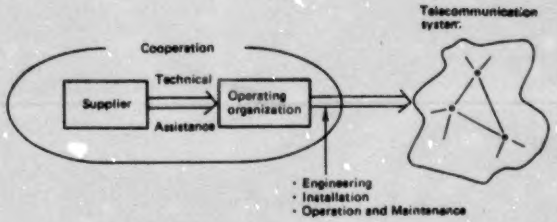


FIG. 2 TECHNICAL ASSISTANCE FOR TELECOMMUNICATION SYSTEM

2.2 ANALYSIS OF TECHNICAL ASSISTANCE

Now, let's analyze the contents of technical assistance for the telecommunication system.

- Works in system life cycle

  Works required through the life cycle of the telecommunication system include the feasibility study mainly evaluating the system applicability as viewed from social and economical conditions, possibility of interworking with the existing network and system expansibily; various planning works such as the network and office construction/expansion planning based on demand forecast and dynamic statistical population predication; various installation related works such as the office design involving calculation of necessary equipment quantity and power capacity, construction work planning, construction work and software file generation; and operation and maintenance works such as daily operation, subscriber line/trunk test, networks monitoring, fault detection, diagnosis, fault recovery and preventive maintenance. Technical assistance for smooth execution of each work is necessary.

- Worker level

  For execution of these works, the necessary jobs and their levels are different depending on the duties of manager, engineer and technician. The necessary technical assistance vary according by.

- Timing and urgency

  With regard to the necessary timing, technical assistance is classified into prescheduled assistance such as training and unpredictable assistance such as temporary countermeasures for emergencies caused by sudden failures and accidents. The allowable period from the time when the technical assistance becomes necessary until actual supply is different because some-critical faults require realtime responses while other faults allow some more time.

- Assistance method

  Various technical assistance works so far explained can also be categorized into those supplied by men or organization such as training and consulting by high-class engineers and those supplied by the systems (machines). The technical assistance functions supplied by the systems will include the menu mode MML (Man-Machine Language) and its help functions provided by the switching system itself, centralized maintenance functions provided by the Centralized Maintenance and Operation Center (CMOC) as well as the inquiry function and remote maintenance function using the fault information data base provided by the Technical Assistance Center.

- Assistance patterns

  There are various ways in which the actual technical assistance is provided. Some examples are knowledge or know how transfer such as training, documentation and data base inquiry; consulting service in response to the inquiry from the customer; and services as proxy such as recovery of important emergent faults and office software file generation (office data generation) to be executed according to the requests from the customer.

As explained so far, technical assistance is classified into many kinds by the job contents, level of the person in charge of execution, supplying method (men, organization or system), required timing, urgency and supply pattern. It is necessary to establish a comprehensive technical assistance system to handle all of these services.

2.3 BASIC CONDITIONS TO REALIZE OF EFFICIENT TECHNICAL ASSISTANCE SYSTEM

Economical realization of the ISDN has become possible by technological advancement in the hardware represented by the VLSI and the software for effective control of the hardware. The ISDN is a very complicated complex of various high-tech products. As compared with the conventional telecommunication system, further refining of the planning, operation and maintenance is necessary. In other words, wider and deeper knowledge is required in effective, highly reliable operation and maintenance because of increasing types and complication by functional improvements of subscriber terminals, network complication by incorporation of various functions into the network and increasing importance of the telecommunication system in the society.

Therefore, the volume of information required for effective technical assistance has been increasing. Quick, reliable transmission and processing of the information has become an important task.

- Incorporation of technical assistance service into ISDN

  It is not economical to construct another dedicated network for transmission of the necessary information for the technical assistance. Transmission of the technical assistance information shall be grasped as one of the telecommunication services and incorporated in the digital network by No. 7 Common Channel Signalling System.

- Overcoming distance

  For continuous supply of high level technical assistance, it is necessary to overcome inconveniences resulting from the distance between the countries of the operating organization and supplier. Although the technical assistance service will be incorporated in the international No. 7 CCS network in the future, the distance handicap will be solved by the international network using the existing satellite or submarine cable communication.

- Strengthening information processing capability

  For efficient collection, storage, processing and supply of increasing technical assistance information, effective introduction of general purpose computer technologies including the data base function, TSS function and information processing function.

As stated above, incorporation of the technical assistance service to the ISDN, establishment of the international network for transmission of necessary information for technical assistance as well as introduction of the general purpose computer having a large data processing and storage capacity are the basic conditions for realization of the effective technical assistance system.

2.4 CONCEPT OF TECHNICAL ASSISTANCE

The really effective and highly reliable technical assistance in the digital communication age which has just made a beginning and is expected to show quick advancement and development while allowing flexible incorporation of rapidly advancing technologies and telecommunication functions, will be implemented according to the following concept:

- Realization of the efficient operating organization's own technical assistance system consisting of top class engineers of the operating organization as well as the organization and supporting functions to enable close cooperation between the operating organization and supplier to complement the operating organization's activity.

- Realization of the flexible and well-coordinated technical assistance system that can provide optimum technical assistance according to the situation and purpose such as the job content, worker level, necessary timing, urgency, supply method and pattern

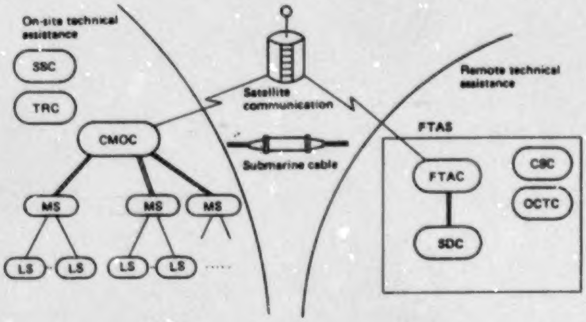
- Application of high-speed, high-reliable communication method for operation, maintenance and technical assistance information to realize well-coordinated operation of various component units of the regionally distributed telecommunication system, and application of the general purpose computer technologies to enable high-speed, sophisticated processing of the increasing operation, maintenance and technical assistance information.

3. TECHNICAL ASSISTANCE SYSTEM

According to the concept described in the preceding chapter, a comprehensive technical assistance function will be provided, by establishing an international network of general purpose computers and the telecommunication system, to smoothen cooperation between the operating organization and Fujitsu and to enable the optimum technical assistance according to the situation and purpose.

For realization of this function, wide technologies and experience of Fujitsu such as switching, transmission and carrier techniques accumulated over many years as well as the most advanced general purpose computer and system configuration technologies are utilized.

FIG. 3 shows the overall configuration of the technical assistance function provided by Fujitsu.



SSC: Software Service Center
TRC: Training Center
CMOC: Centralized Maintenance and Operation Center
MS: Tandem Switch
LS: Local Switch
FTAS: Fujitsu Technical Assistance System
FTAC: Fujitsu Technical Assistance Center
SDC: System Development Center
CSC: Customer Support Center
OCTC: Overseas Customer Training Center

FIG. 3 OVERALL CONFIGURATION OF TECHNICAL ASSISTANCE

The CMOC system is provided as the center of the on-site technical assistance to facilitate configuration of the technical assistance system by the operating organization itself. The on-site technical assistance system also includes the SSC (Software Service Center), TRC (Training Center) etc.

The whole system provided as remote technical assistance is called the FTAS (Fujitsu Technical Assistance System). With the FTAC (Fujitsu Technical Assistance Center) as the front end, comprehensive and consistent technical assistance will be provided by the CSC (Customer Support Center), SDC (System Development Center) and OCTC (Overseas Customer Training Center).

3.1 ON-SITE TECHNICAL ASSISTANCE

Economical and highly efficient overall technical assistance for the daily operation and maintenance by the customer of the telecommunication system by way of the electronic switching system, centralized maintenance and operation center (CMOC), software service center (SSC), training center (TRC), network control center, subscriber administration center, repair center, etc.

(1) Functions built in the electronic switching system itself

- Menu mode MML and command input method by the help function
- Online fault diagnostic function using electronic diagnostic dictionary

(2) CMOC (Centralized Maintenance and Operation Center)

Various functions for centralization of the operation and maintenance provided in the CMOC enable each office and the whole network to be operated and maintained efficiently. At the same time, centralized assignment of high-class engineers and the communicate function with each office make effective technical assistance possible.

FIG. 4 shows the CMOC system configuration, and TABLE 1 shows the function list.

TABLE 1 FUNCTIONAL OUTLINE OF CENTRALIZED MAINTENANCE AND OPERATION CENTER

Centralized Testing Subsystem	MLTCNS Master Line Test Console	Testing of subscriber lines
	MSTCNS Master Supervisory and Test Console	Testing of lines and trunks
Centralized Supervisory Subsystem	ALMR Alarm Receiver	Display of contents of alarm data collection of exchange
	ALDE Alarm Display Equipment	Graphic display of the position/ content of alarm data of exchange
Centralized Operation Subsystem	Remote VDU	Centralization of man-machine interface of exchange
	Man-Machine History Management	Storage and retrieval functions of all man-machine history data within a network
	Command File	Cataloging of command strings and automatic executing function
	Data Collection	Automatic collection of various application data
	Statistics Processing	Statistic and graphic output of various application conditions
	Alarm Management	Management of faults and their recovery conditions

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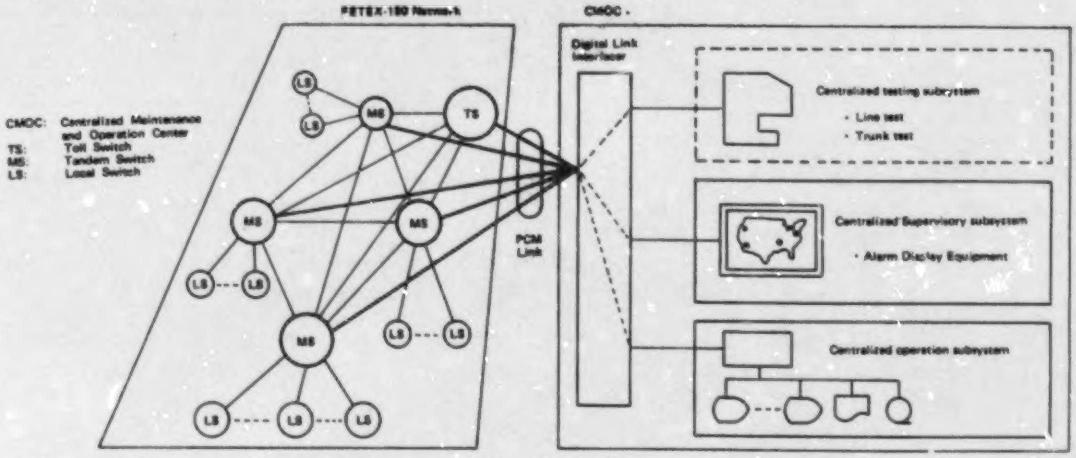
FETEX-150 Network
CMOC:	Centralized Maintenance and Operation Center
TS:	Toll Switch
MS:	Tandem Switch
LS:	Local Switch
LS
LS
MS
TS
MS
MS
LS
LS
MS
LS
LS
LS
LS
LS
PCM Link
CMOC
Digital Link Interface
Centralized testing subsystem
· Line test
· Trunk test
Centralized Supervisory subsystem
· Alarm Display Equipment
Centralized operation subsystem

FIG. 4 CENTRALIZED MAINTENANCE AND OPERATION CENTER CONFIGURATION

(3) SSC (Software Service Center)

The electronic switching system software has attained commonization of the system program by generating the each office's conditions, such as the number of trunks, trunk types, route information, etc. that vary from office to office, as the data. Various programs (DGN: Office Data Generator, CGN: Office Condition Regenarator, etc.) for efficient data generation are provided. The SSC is prepared as the center to carry out data generation and software program modification and editing.

(4) TRC (Training center)

The training center may be prepared for training of the operation and maintenance of the office and network. It is a kind of a small scale switching office. It is configured to make training for operation of multiple ranks of offices such as LS, MS and TS by one system possible. It is also possible to let the training center have the SSC function, so the software service and training center can be installed economically.

3.2 FUJITSU TECHNICAL ASSISTANCE SYSTEM (FTAS)

The organizations and center systems (machines) for the remote technical assistance are called collectively as the Fujitsu Technical Assistance System (FTAS).

The FTAS consists of two center systems and two organizations to provide optimum, flexible technical assistance according to the required situation and purpose. By interworking of the center systems and organizations, a high-quality reliable technical assistance function is provided.

- FTAC (Fujitsu Technical Assistance Center)

This is the front-end machine of the FTAS having the function to retrieve various information and the function to provide remote maintenance service by Fujitsu's engineers.

- CSC (Customer Support Center)

This is the specialized organization for customer (operating organization) support which carries out acceptance of various requests from the customer, consulting and delivery jobs.

- OCTC (Overseas Customer Training Center)

This is the specialized organization for execution of various types of training.

- SDC (System Development Center)

This is the main center for system development. In addition to development support, it supplies various latest information as the back-end center of the FTAC.

The development organization consisting of engineers having sufficient experience and capability as the back-end of the FTAS provides powerful support to the CSC, OCTC and FTAC.

FIG. 5 shows the FTAS configuration.

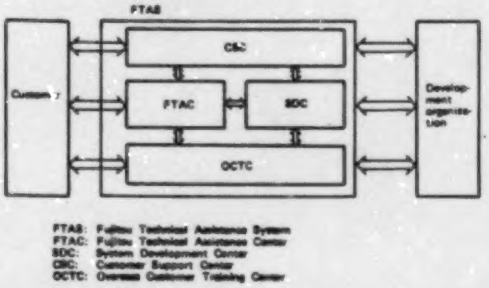
FTAS
Customer
CSC
FTAC
SDC
OCTC
Development organization
FTAS:	Fujitsu Technical Assistance System
FTAC:	Fujitsu Technical Assistance Center
SDC:	System Development Center
CSC:	Customer Support Center
OCTC:	Overseas Customer Training Center

FIG. 5 CONFIGURATION OF FUJITSU TECHNICAL ASSISTANCE SYSTEM

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3.2.1 FUJITSU TECHNICAL ASSISTANCE CENTER (FTAC)

This is the front-end host center that can be accessed freely through the international telecommunication line. It provides the inquiry function to the fault information, technical information and other data bases, online consulting with OSC engineers, and remote maintenance service. For the customer not introducing the SSC, the function as the remote SSC may be provided.

FIG. 6 shows the FTAC configuration, and TABLE 2 the functional outline.

TABLE 2 FUNCTIONAL OUTLINE OF FUJITSU TECHNICAL ASSISTANCE CENTER

SYSTEM NAME	FUNCTIONAL OUTLINE
FIND	Technical information and document retrieval function
FIRES	Software/hardware fault information retrieval function (symptom, cuase, remedial action, etc.)
OCDS	Office design support function (Equipment quantity calculation, office data generation, subscriber data generation, system file generation, etc.)
CIAS	Customer information administration function (Equipment configuration, application function, update history information administration data base)
ESPAS	Software products administration system (Automatic warehouse and retrieval system for design documents, lists, storage media, etc.)

3.2.2 CUSTOMER SUPPORT CENTER (CSC)

This is the specialized organization for customer (operating orgainzation) support. It provides consulting service by skilled software and hardware engineers, software customizing execution and delivery, faulty parts repair, spare parts supply and other services directly to the customer while carrying out good administration of the whole FATS including operation and maintenance of the FATC as well as maintenance of various data bases.

The CSC consists of three groups: the customer engineering group for telecommunication system engineering, planning and support service for each customer, the product engineering group for software file customizing and quality assurance service, and the customer service group for public information and spare parts supply service. These groups provide high-quality, advanced customer support by close mutual cooperation.

(1) Customer engineering group

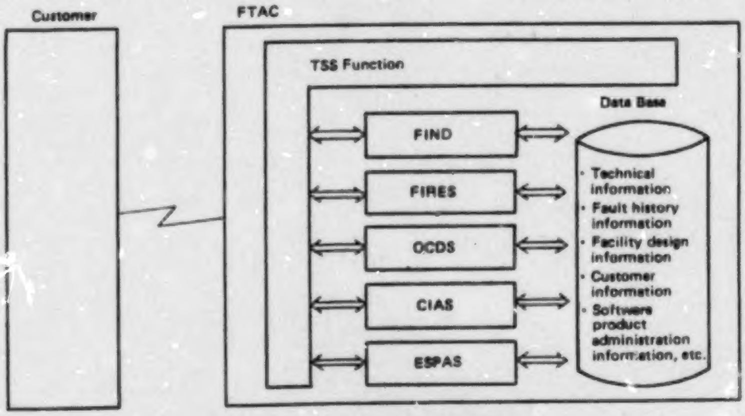
This is the group to support necessary engineering such as the network design and office design for each customer. It provides supports and proxy execution of equipment quantity calculation, office data generation, network expansion planning and equipment expansion planning as well as various consulting services.

(2) Product engineering group

This group carries out inspection, delivery and information management of hardware and software products. Examples are software file customizing to supply the system complying the customer specification, final quality check and delivery information management of products supplied to the customer, supply of software file amendment information and management of its history.

(3) Customer service group

This group helps smooth operation of the


Customer
FTAC
TSS Function
Data Base
FIND
FIRES
OCDS
CIAS
ESPAS
· Technical information
· Fault history information
· Facility design information
· Customer information
· Software product administration information, etc.

FIND: Fujitsu Information Retrieval Service for Program and Document
FIRES: Fault Information Retrieval System
OCDS: Office Condition Design System
CIAS: Customer Information Administration System
ESPAS: ESS Software Products Administration System

FIG. 6 FUJITSU TECHNICAL ASSISTANCE CENTER CONFIGURATION

telecommunication system through such services as public information, spare parts supply, defective item repair and expendables supply control, and supplies various up-to-date information by management of various data bases such as fault history and technical information data bases in the FTAC as a part of FTAC management.

3.2.3 OVERSEAS CUSTOMER TRAINING CENTER (OCTC)

This is the specialized organization for planning and execution of training as the first step of technical assistance that provides the basis for various later technical assistance services.

The training courses to be provided by this center covers each system type such as the switching system, cable carrier system or radio relay system with the matrix type curriculum considering job contents like engineering, installation, operation and maintenance as well as the trainee level such as managers, engineers or technicians. The optimum course satisfying the customer requirements can be selected.

Each course consists of the lecture and practice in proper order and at a proper ratio to obtain the maximum effect. The latest training aids and sufficient hardware for practice required for the purpose are provided. Training is divided into training in Japan and training in the customer's own country. In the training in Japan, effective training by trainers having sufficient knowledge and experience regarding the system and training method is carried out. In the training in the customer's own country, on-the-job training by using the customer's training center and the site/station equipment is carried out.

3.2.4 SYSTEM DEVELOPMENT CENTER (SDC)

The various technical assistance provided through the FTAC, CSC and OCTS are backed up by advanced know how accumulated through Fujitsu's long experience in development of telecommunication systems and skilled engineers. The SDC is provided as the support center for the development know how and activities to realize efficient development of the high-quality, high-reliability system and to continuously supply living technical information by interlocking with the FTAC, CSC and OCTS. Most essencial foundation for effective technical assistance is to supply a system products provided with highly reliable and powerful operation and maintenance functions. For this purpose, SDC is provided as the support system for highly reliable and efficient system development. The SDC is the advanced design, production, test, inspection and development management support system, realized on the computer complex consisting of the general purpose computer, backup machines and various environment simulators. FIG. 7 shows the SDC configuration.

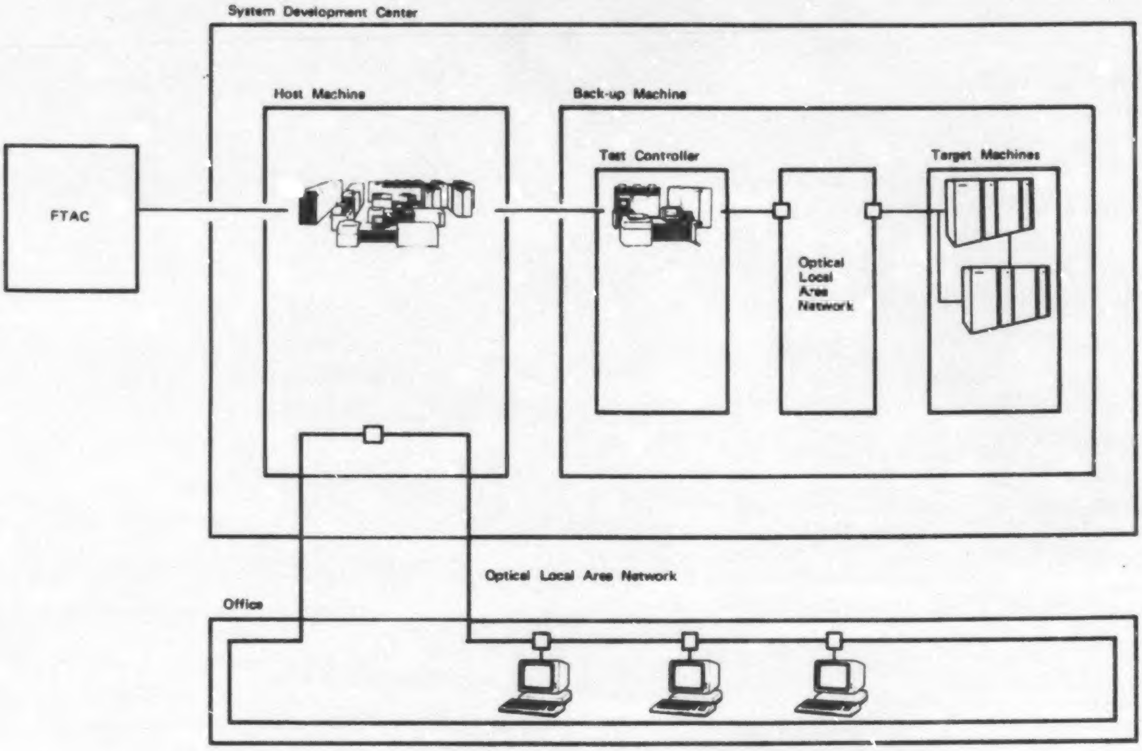

System Development Center
Host Machine
Back-up Machine
Test Controller
Target Machines
FTAC
Optical Local Area Network
Optical Local Area Network
Office

FIG. 7 CONFIGURATION OF SYSTEM DEVELOPMENT CENTER

The concept for attainment of high reliability and efficiency in developing the software whose importance has been increasing for realization of the functions and reliability of the telecommunication system is explained below together with the support functions realized by the SDC.

The telecommunication software features a wide range from the large-scale switching system software (several hundred K steps to several M steps) to the small-scale firmware, various switching office scale from a small one (several hundred subscribers) to a large one (several ten thousand subscribers), requirement of supermultiplex realtime processing, and requirement of high reliability ensuring highly stable operation for several decades. Therefore, necessity of providing the assembler, linker and other basic development support tools for each processor types in use, difficulty of exclusive use of high level languages for development (combined use of high-level languages and assemblers), and complication of control logic and program structure are the problems requiring solution.

For efficient development of high-quality software by solving these points, the development environment to follow the software development activities technologically in the phases of development technology and methodology (SDT: Software Development Technology), standardization of development jobs and techniques (SEN: Software Engineering Norm), development support tools (FESS: Fujitsu Extensible Support System), and development management system (SMS: Software Management System) is constructed.

The FESS is a group of development support tools provided in the SDC.

The FESS has been prepared and is extending its function so to speak a CAD/CAM system for the software. It consists of various support functions as described below considering the software life cycle.

- Specification and description language SDL (functional specification and description language recommended by CCITT) support system

  Formal description, execution and verification in specification level, program code generation, document generation function, etc. using the knowledge base technology.

- Program description high level langauge support system

  Optimization complier, document generation, program evaluation, configuration control function etc.

- Test support system

  Test support functions on host computer such as the HLL symbolic debugger, test data generation, stub/driver generation, etc., and target test support functions such as environment simulators (TECS: Test Call Simulator, PCT: Pseudo Call Tester), dynamic route simulator (PROT: Program Route Tester), sophisticated console (ICS: Integrated Console System), remote test system using optical-fiber LAN (software file high-speed loading function, test result data transfer and storage to host computer, etc.), and so forth.

- Development control support system

  Equipment, cost, progress, quality and other control functions to enable the control data to be quickly fed back by the visible display function according to each of the manager, leader and term member levels.

FIG. 8 and 9 show the example of the output of FESS components.

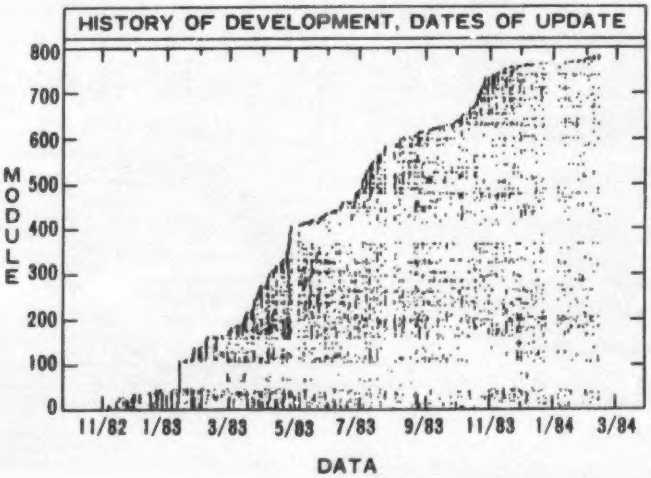


FIG. 8 GRAPHIC DISPLAY OF DEVELOPMENT HISTORY

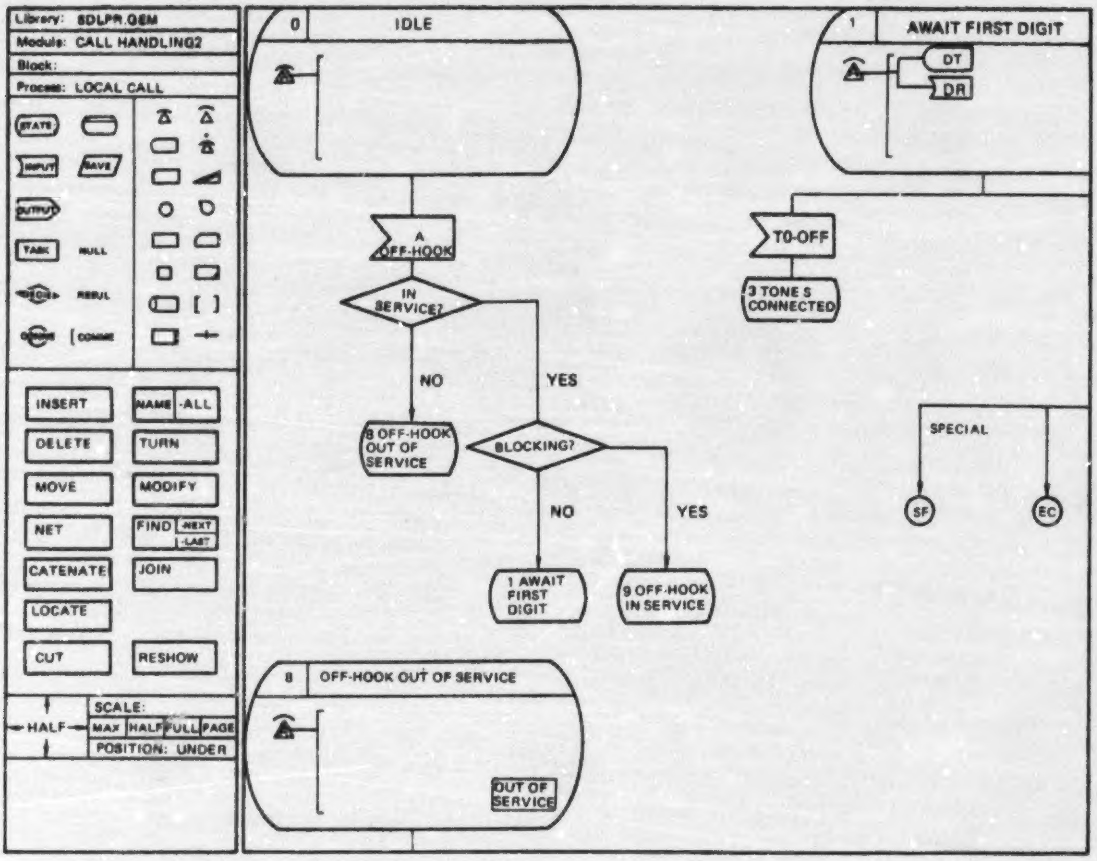

Library: SDLPR.GEM
Module: CALL HANDLING2
Block:
Process: LOCAL CALL
STATE
INPUT
SAVE
OUTPUT
TASK
NULL
DECISION
RESUL
OPTION
COMME
INSERT
NAME -ALL
DELETE
TURN
MOVE
MODIFY
NET
FIND -NEXT -LAST
CATENATE
JOIN
LOCATE
CUT
RESHOW
HALF
SCALE:
MAX HALF FULL PAGE
POSITION: UNDER
0
IDLE
A OFF-HOOK
IN SERVICE?
NO
YES
8 OFF-HOOK OUT OF SERVICE
BLOCKING?
NO
YES
1 AWAIT FIRST DIGIT
9 OFF-HOOK IN SERVICE
8
OFF-HOOK OUT OF SERVICE
OUT OF SERVICE
1
AWAIT FIRST DIGIT
DT
DR
TO-OFF
3 TONE S CONNECTED
SPECIAL
SF
EC

FIG. 9 TERMINAL DISPLAY IMAGE OF SDL SUPPORT SYSTEM

4. CONCLUSION

The concept, function and system outline of the necessary technical assistance for the coming advanced information age with the integrated services digital network (ISDN) as its backborne described above.

The essence of technical assistance, in short, is to provide necessary knowledge, know how and information in effective way. For this purpose, composite organization of a wide range of technologies such as information and knowledge arangement method, storage and processing technology, expression technology, transfer technology and training method is necessary. Sophistication and application of various technologies will be promoted further in the future as an effort to realize the telecommunication system having truly refined operation and maintenance function, and the technical assistance system for effective support of the telecommunication system.

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NETWORK PLANNING WHEN
DIGITAL EQUIPMENT IS INTRODUCED IN AN ANALOG ENVIRONMENT

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Abstract

During the past 100 years the planning of telecommunication networks has been characterised by the search for the most economic location of the central offices and by the search for the most economic alternate routing. The purpose has always been to reduce the investment with a better utilization of the expensive long distance circuits and metropolitan trunking.

The introduction of digital exchanges in an analog environment has created an additional problem in the design of the networks, both long distance and metropolitan: How to economically introduce new digital exchanges and new digital trunks in an analog environment, maximizing the enormous economic advantages presented by the utilization of digital technology.

The conversion of the networks from totally analog to totally digital will take at least 20 years; during this period planners have to evaluate and reduce to the minimum the analog to digital interface.

Three different methods of network planning are examined in detail, with practical examples of real applications.

Finally the integration of speech and data during the transition period of the networks from analog to digital and the limits to the application of the ISDN concept to the evolving configuration

1. INTRODUCTION

Planning of new digital networks is today more similar to the work of an Architect rather than to that of an Engineer. It is an art, it is no more a Mathematical Science, as it has been in the past. Also the Architect requires Engineers and Economists to evaluate how good is his solution; but there is a lot of imagination involved in this process.

The Planner must have great experience in all aspects of the Telecom Science, and must know very very well the evolution of the network he is planning. He has to explore different solutions and demand to the computer to make a comparative analysis.

However, the best solution is not always the most economical today; the evolution of the network should be examined over a long period of time. All networks are today in very large percentage analog and exchanges cannot be replaced until their economic life is achieved.

Conversion of networks from analog to digital will take at least 10 years but more probably 20 years to be completed. All digital components are more economic than the corresponding analog ones; the introduction of ISDN and in general of data in a network is certainly more economic if achieved through the implementation of the digital technology.

Nevertheless, today the new digital equipment must be interconnected to the existing analog and this interconnection is very very expensive.

Consequently, if not properly designed, the digital conversion could be not economically justified. In addition new technologies using the fiber optic cables for outside plant distribution will be certainly introduced in the next 5 years.

The Planner has to take into consideration also future technological improvements to be sure that one economic solution implemented today remains economic when new advanced technologies are introduced.

2. THE REVOLUTION IN THE NETWORK PLANNING PROCESS

In the past 100 years the network planning was essentially limited to the search of the best traffic mix to optimize costly trunking system.

During the same period computer programs based on mathematical traffic theories and alternate routing possibilities have been utilized.

The introduction of the stored program control in the semi-electronic exchanges has not substantially changed the basic philosopny of the network planning process. However considerable economic improvements have been achieved especially in reducing traffic jamming during peak hours.

But the real revolution is today: basically the following points have created a dramatic change in the network planning philosophy.

1. A switched digital erlang requires an investment which is one tenth of the investment required for a switched analog erlang.
2. Digital exchanges could have a single unit as large as required. Without increasing the investment for each subscriber line, remote line units could save substantial investments in the outside plant.
3. The quantity of outgoing trunk groups that can be reached by a single subscriber or by an incoming trunk is very high. Consequently, it is possible to optimize the relation between high usage routes, direct routes and alternate routes.
   Digital exchanges have full availability and loss inferior to 1 x 10 at -8.
4. Costly loaded junction cables in large metropolitan areas are replaced with "zero loss" digital fiber optic cables or digital microwave with a capacity far superior to that of a physical pair cable. Trunks are bidirectional.
5. Digital exchanges can accomodate local and tandem traffic; transit exchanges can accomodate within the same unit zone, regional and national with tandem traffic.
   The traditional distinction between class 2-3-4 offices disappears.
6. The space required for a digital transit exchange is minimum when compared to an equivalent analog one.

All above economic advantages are jeopardized by the fact that today all digital new equipment must be interconnected with old analog existing equipment. Each interconnection, at channel level, requires an analog to digital converter and a signalling converter.

Consequently the basic goal of the planner is:

> "Take maximum advantage of the low
> "cost of switching and transmit
> "digital traffic, reducing to the
> "minimum the traffic between analog
> "and digital networks."

In the meantime the design of the network must take into consideration the introduction of the following technological improvements available today or in the near future.

Create huge traffic flow between digital exchanges introducing the common channel signalling (CCIS or CCITT #7)

Eliminate congestion in analog exchanges.

Improve the service of analog exchanges by controlling, with the computer of the digital exchange, the analog trunks from and to an analog exchange.

Prepare the network to the introduction of an integrated ISDN.

Centralize in a single location, maintenance, network control, network operation, traffic records, etc.

In areas where outside plan expansion requires huge investment, the installation of digital "remote line units" can represent considerable savings

The following three examples A, B, C, will give a practical description of the proposed design methodology that will permit to achieve the maximum savings in the introduction of digital equipment in an analog environment.

A. THE HIGH TRAFFIC PARALLEL NETWORK

At first glance it appears that a good economic solution is to replace an exhausted analog exchange with a new digital one. Manufacturers suggest always new digital in new building as the best solution. Certainly large digital exchanges have a basic price per line lower than small ones

But all interconnection to the rest of the network is analog and expensive. The MDF is to be replaced and costly cable termination must be installed.

When, gradually the network evolves from analog to digital the investment for analog to digital interface is to be eliminated and cannot be reutilized.

The operating telephone companies, on the contrary, consider that it is much better to expand an analog exchange with digital additions.

Obviously if only one exchange is expanded the only advantage is to transfer the high traffic subscriber to the new exchange; consequently the overload of the old exchanges is relieved.

But examine the possibility of creating a new digital network in parallel with the existing one as shown in figure 1.

Install in strategic sites in the same building of the existing exchange a new digital expansion with very high traffic capacity.

Transfer to such exchanges all heavy traffic subscribers and other special subscribers requiring a first class services and possibly

INTEGRATION OF THE HIGH TRAFFIC DIGITAL NETWORK WITH THE EXISTING ANALOG NETWORK

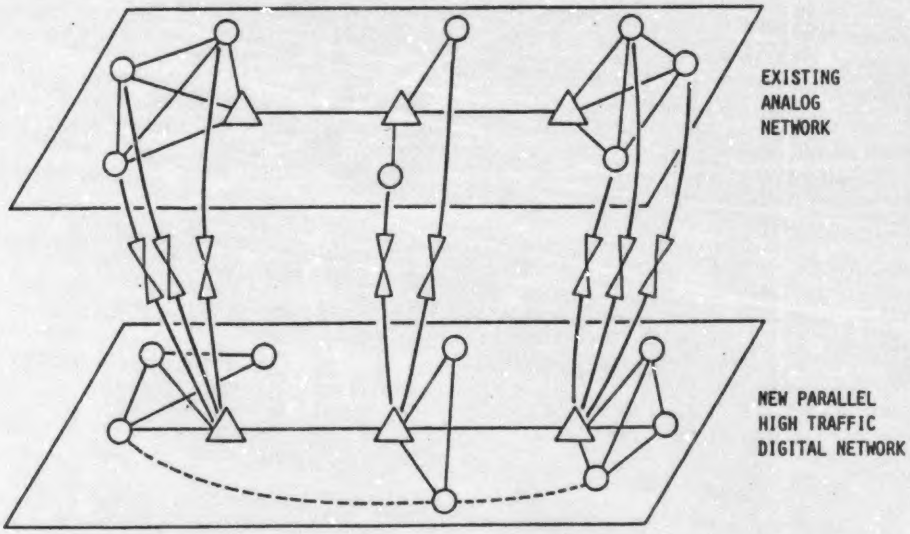


FIG. 1

paying additional fee for the new features.

Interconnect digitally among them all new digital exchanges.

It has been proven that 5% of the subscribers of a metropolitan area produce 35% of the total traffic during the busy hour. Every year, every telephone administration invests 5% of plant original value in new equipment.

The suggested parallel network will certainly double or triplicate the revenues corresponding to the new investment.

A calculation will show that the analog to digital interconnection will be reduced to the minimum because the community of interest factor between the old and new collocated exchange will be reduced; no equipment will be added to the old exchange; the MDF and outside plan configuration will remain the same; new remote units will solve problems of insufficient outside plant in some areas; long distance traffic can be terminated in the digital exchange without requiring transit through a long distance exchange.

B. THE PCM RING FOR THE LARGE METROPOLITAN AREAS AND LONG DISTANCE NETWORKS.

In order to prove the efficiency of the introduction of digital transit exchanges we consider an hypotetical case where the planner has to design a network in a new area where no telephone system has ever been installed. Computer will give the ideal economic solution "THE PCM RING"

The figure 2, in this page, shows a

THE PCM RING

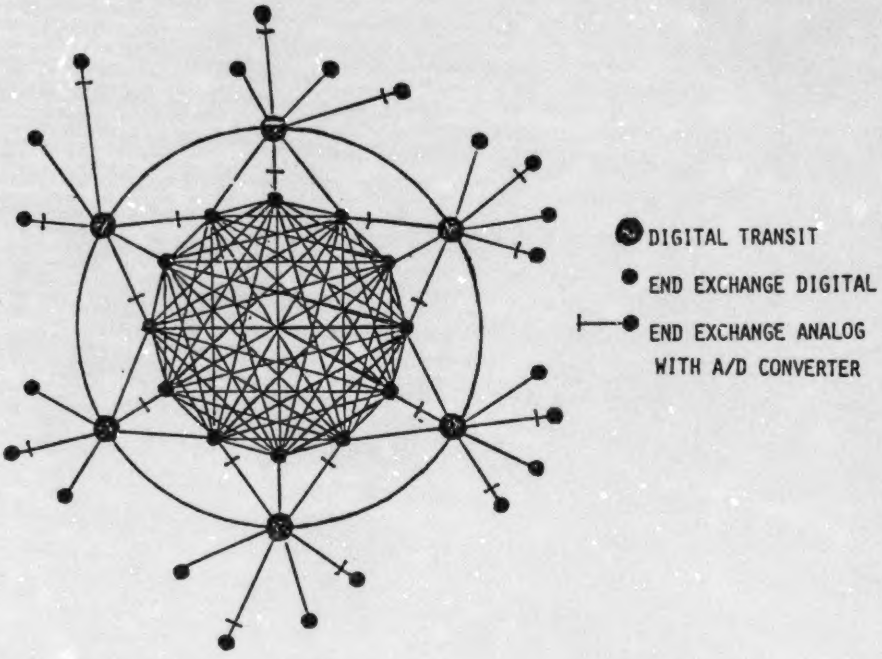


FIG. 2

design of a network in a metropolitan area where transit exchanges are all digital and local exchanges are either digital or analog.

A similar configuration can be made for a long distance network PCM ring.

Digital transit tandem exchanges located in the most important centers or gravity of each area (either in one section of a metropolitan area or in one city) will be interconnected among them digitally to form a mesh; terminal exchanges will be connected to the transit and or tandem exchanges

When we are in a realistic case, the advantages do not disappear if the tandem/transit exchanges are digital.

Star connected existing analog exchanges will increase their trunking efficiency due to the low cost of the switched erlangs. But the advantages are several and we list here below only the most important ones:

> The PCM ring has a huge capability of transit/tandem traffic with an illimited capacity of alternate routing. Trunking congestion is virtually eliminated.
>
> If the transit exchanges are prepared for the ISDN the entire network could become an ISDN network from/to any new ISDN subscriber.
>
> The common channel signalling system CCIS or CITT #7 will offer to all network the advantages and features it has been designed for.

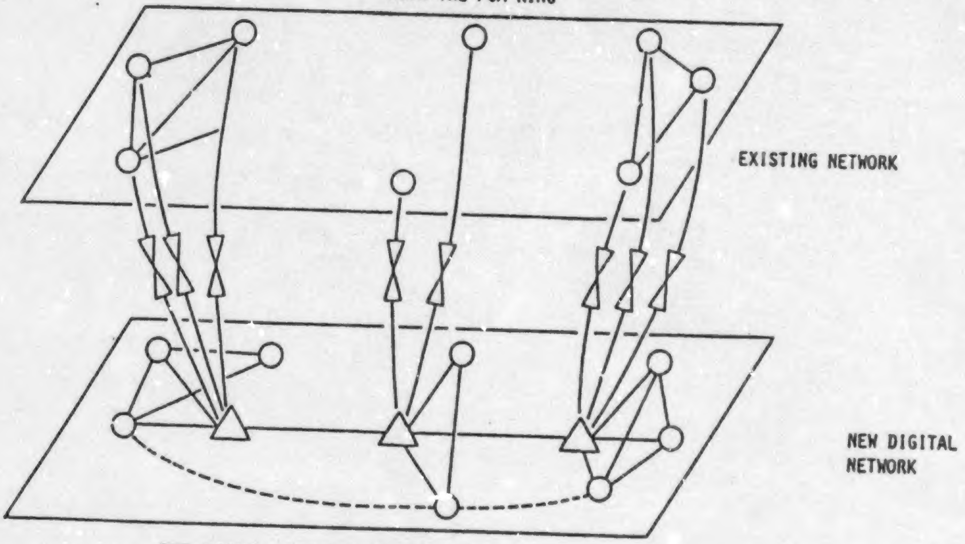
C. THE COMBINATION OF THE PCM RING WITH THE PARALLEL NETWORK.

From the two examples above we can deduct that the most economic introduction of digital exchanges in an analog environment is the combination of the PCM ring with the parallel high traffic network.

As shown in the fig. 3, in the previous page, examining in detail the configuration of this network we can see that the changes of the existing local exchanges are limited to the changes of trunk assignment. Basically the structure of the analog network remein the same.

The change is in the routing of traffic. The traffic between neighboring analog exchanges remain unchanged. When a substantial distance exists between two

INTEGRATION OF THE HIGH TRAFFIC NETWORK
WITH THE PCM RING



THE ANALOG TO ANALOG CONNECTIONS ARE ELIMINATED.

FIG 3

analog exchanges, the flow of traffic is routed through "Highways" of illimited capacity of traffic. These highways connect all centers of gravity in a mesh of full availability and "zero loss".

Old and new exchanges will benefit of an ideal situation for the introduction of many new features.

Common channel signalling

Centralized maintenance and operation.

3 GRADUAL AND COMPLETE UTILIZATION OF THE ISDN NETWORK

The ISDN network has been the argument of the most important presentations during the recent ISS symposium. Nobody can underevaluate the importance of the ISDN network and the fact that both the suppliers and the telephone operating companies must be prepared to the introduction of such network to satisfy the requirements of a modern office.

However, it is to be understood that the introuction of the ISDN network starts from two sides:

from the subscriber side: the first step is to eliminate the double subscriber loop required for speech and data. This step is available today and can rapidly be introduced in all subscribers loops.

On the exchange side: ISDN is to be introduced in the transit/tandem exchanges; such exchanges must be transparent to both speech and data. Otherwise a local digital exchange with ISDN facilities can introduce data traffic only among subscribers belonging to the same exchange.

The explanation given for the parallel network and the PCM ring is clearly the first step that allows the introduction of the data subscribers into the network.

Certainly not all the telephone subscribers will require in the near future the ISDN; may be 5 or 10 %.

The parallel network is the solution which allows a rapid introduction of digital data network available today.
Once the problems of standardization of the ISDN protocols are solved, suppliers will manufacture digital subscriber termination unit for speech and data and the software will be able to switch data traffic.

All these efforts are useless if the tandem/transit exchanges are not installed with data switching capability. Local exchanges prepared for ISDN will require separate data networks and the economic advantages of the ISDN will disappear.

4 CONCLUSION

When the introduction of digital equipment in an analog environment is planned by the telephone operating companies, the most important consideration is that not all subscribers need all the technological advantages that the introduction of modern digital equipment made possible.

However, the telephone operating companies should capitalize of those advantages with increased revenues and reduction of operating cost.
Consequently, it is to be accepted the principle that subscribers can be subdivided in class 1 and 2: The class 1 belongs to the priviledged subscriber that have a very high traffic or desire modern features at an extra cost; the class 2 includes all other subscribers with low traffic and no demand for special services.

Subscribers of class 2 are badly compensating the telephone company for the service they receive; there is no reason to invest more money for new digital equipment for subscribers of class 2, they will continue to be satisfied with the service offered by the analog exchanges until the useful life of those exchanges is expired.

Computerization of Telecommunications Operations for a Digital World

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1. ABSTRACT

The introduction of computerized support systems into telecommunications operations is essential if the full benefits of digital switching are to be realized. This paper suggests the adoption planning methodology, Operations Planning, that has been widely accepted in the United States. This methodology, coupled with state-of-the-art distributed systems, will allow any telecommunications provider to realize benefits quickly, while building for the future as well.

2. INTRODUCTION

The purpose of this paper is to present a practical approach to computerizing telecommunications operations in a telephone operating company. Although there is no single approach that will meet the needs of every provider, the author's experience in the US and ten other countries has led to the conclusion that certain universal principles can be applied to create a planning approach that has world-wide applicability.

The availability of large digital computers was immediately followed by their introduction into telephone company operations. Billing and engineering design systems were among the first to derive immediate benefit from computerized applications. Since that time, every area of telephone operations has been affected by and benefited from computers.

As computer software and hardware has become more sophisticated and telephone company investment in these tools has become more extensive, a greater emphasis on planning for computerization has occurred. Because of the need for individual systems to interact and share data, this planning quickly evolved into a highly complex, specialized discipline called Operations Planning. The first Operations Plan created by AT&T and the Bell Operating Companies was called TNOP (Total Network Operations Plan).

As a telecommunications provider adopts digital technology in its network, the benefits of Operations Planning become ever greater, for they allow for the integration of the support features that are available in most digital exchanges with manual and mechanized systems added exogenously.

For example, when an analogue, electromechanical switch begins to fail, typically service to the customers degrades slowly. However, when a stored program controlled (SPC) switching system fails, it fails catastrophically and hence requires closer monitoring, if high-quality service is to be maintained. Operations systems are particularly useful in supporting this activity.

This paper discusses the fundamentals of Operations Planning, the design of Operations Systems, and the integration of computerized systems into operations.

3. FUNDAMENTALS OF OPERATIONS PLANNING

The Fundamental Elements of Operations Planning are:

1) The Operations Functions;
2) The Operations Centers;
3) The Operations Systems; and
4) The Operations Processes.

These will all be described below.

3.1 THE OPERATIONS FUNCTIONS

Every telephone company shares a common mission -- provide cost effective telephone service. To meet this objective, certain basic functions must be carried out. Examples of these functions (among many others) are:

. Trunk engineering;
. Subscriber line maintenance;
. Billing; and
. Service Order Processing.

The author's research and experience indicates that the telecommunications functions are identical from country to country, even though the way these functions are carried out around the world may differ markedly. The impact that this finding has on Operations Planning and Systems' design will be discussed below.

3.2 THE OPERATIONS CENTERS

An Operations Center (Center) is a group of workers reporting to a common manager and carrying out a related function for a specified geographic area. The definition of the Center also defines the organization of the company. Examples of Centers might be:

- Installation and Repair Garage;
- Trunk Operations Center;
- Network Management Center;
- Commercial Office; and
- Account Inquiry Center.

As technology changes or the goals and objectives of the organization change, Centers may be created, modified, or phased out to meet changing needs. This type of change is facing most telecommunications providers as they introduce digital switching into their networks.

For example, control of software generics on SPC switching systems has no analogue in the "non-digital" world and would likely require a new Center.

3.3 THE OPERATIONS SYSTEMS

An Operations System (System) is a computer-based tool that is used by workers and managers in a telephone company to assist them in carrying out their jobs.

Systems should be designed to support the Operations Functions so that they may remain stable to maturity. They must be carefully planned, if this goal is to be realized. There is a strong tendency to design Systems to support Centers. If the Centers are changed (e.g., the company is reorganized), then the System may need to be scrapped or modified. However, since the Operations Functions are stable (as stated above) designing Systems to carry out Functions rather than to support Centers lends a stability to the intrinsic design of the Systems.

3.4 OPERATIONS PROCESSES

An Operations Process (Process) is a formalized diagram of the work flow needed to carry out an Operations Function. It is the Process that ties together the Centers and the Systems.

Process analysis is valuable before, during, and after mechanization, for it allows managers to understand the impacts on any changes in organization (Centers) or Systems or on the introduction of new technology (e.g., digital switching).

A central thesis of Operations Planning is that Process analysis should precede the design of Systems to determine which Functions should be computerized and in what timeframe. Hence, the Process analysis must involve the affected members of the line operations department, staff members who understand the Operations Planning discipline, and Systems designers.

Typically, most telecommunications providers have found that billing, service order processing, remote surveillance and maintenance, and engineering applications are best to computerize first from an economic and social point of view.

Usually the current Process is defined first. This reflects the current organization of the Centers and existing goals of the organization (e.g., universal service).

The Operations Planning team then creates a 1-2 year view that might reflect any of the following:

- Pending reorganizations;
- Changing business or service goals;
- Known introduction of new network technology; and/or
- Known social, political, or regulatory changes.

This plan should reflect a fairly accurate view of the environment that any System being developed should face when it first comes on-line.

The Operations Planning team then creates a longer term (typically 5 year) view (Process) that would include Systems that should be deployed by that time. The five-year Process is the basis for the definitions of the feature specification for the Systems to be developed.

The difference between the One- to Two-year and Five-year Processes allows the planning team to assess the impact of the Systems introduction, both from a financial point of view and from the impact on the work force.

The remainder of this paper will address how Operations Planning may be used to design Systems that have the flexibility to grow with the "Digital World."

4. DESIGN OF OPERATIONS SYSTEMS

4.1 OPERATIONS SYSTEMS ARCHITECTURE

Part of a good Operations Plan is a good Systems Architecture or blueprint for the long-term design of Systems that meet the ever-changing operations needs of the company in a graceful way. Such an architecture must take into account that digital switching systems are another form of computer that has both data analysis and control features. It is essential that any architecture, therefore, accommodate the distributed nature of the telecommunications system.

Fortunately, computer and software technology has moved (and will continue to move) in the same direction.

The Systems Architecture defines how the System applications are logically constructed and connected together. One part of the Systems Architecture is the data architecture that defines how the different types of data that are necessary for telecommunications operations will be layered and shared among the applications. Much work has been expended on the study of alternate data architectures for telecommunications operations.

Great care must be taken to design logical architectures first and then the physical implementation of that architecture later. A separate logical design will allow the overall systems design to be implemented on whatever state-of-the-art equipment and software is most appropriate for the logical design.

A word of caution about the dangers of "Conversational Engineering." Most telecommunications engineers who are untrained in software engineering but are given the systems design task usually revert to talking through the design without sufficient Operations Planning. We have termed this exercise "Conversational Engineering." Although it has its place, the long-range design of Systems requires much experience, discipline, and skill.

4.2 SIZE AND SCOPE OF THE SYSTEMS

When confronted with the need to have an integrated set of Systems with a consistent data architecture, planners often attempt to design a single physical implementation of this system. This raises the question: How many Processes should be fully supported by Systems?

Let's examine two alternatives:

(1) A big system that does all things for all people; and

(2) A little system with limited functionality.

4.3 THE BIG SYSTEM

From a planning point of view, it often appears that the single, integrated system is the simplest solution to computerization. To use the analogy of the telephone network, this would be like creating one, huge switching system to serve all subscribers. In principle this might seem appealing since, for example, one would never need toll facilities.

Although this example seems ridiculous enough in common telephone terms, many companies have attempted to implement an analogous system to computerize operations. Such systems share certain characteristics:

- System requirements change constantly;
- Expenses grow exponentially with time;
- Resources are limited;
- System is never completed; and
- No one is ever satisfied.

Although such a Systems design is appealing from a conceptual viewpoint, it is not practical, especially for a company with limited computer resources and experience.

4.4 THE SMALL SYSTEM

Faced with rapidly proliferating personal computers, one solution that has been tried by many telecommunicators providers is creating a myriad of small System applications inexpensively on these small processors. However, the small system solutions tend to ignore the lesson of Operations Planning, since these small applications typically cannot be integrated with one another and do not have the flexibility to support an entire Process. Furthermore, their ability to link with or integrate with switching systems is limited.

4.5 THE LESSONS OF DISTRIBUTED SYSTEMS

With careful Operations Planning, the best attributes of the Big System and Small System may be combined to computerize telecommunications operations. AT&T's experience has shown that a vertically integrated, distributed systems architecture may provide the needed systems design, without the pitfalls noted above.

AT&T Bell Laboratories and other AT&T units have researched and implemented vertically integrated Systems over the last decade. Two of the keys to such systems are:

- An appropriate operating system that is somewhat hardware independent; and
- A common data dictionary.

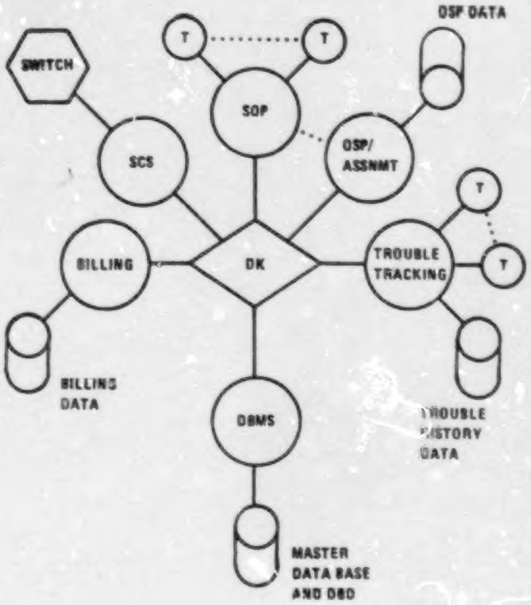
AT&T Bell Laboratories has developed UNIX^{TM} to serve as the common element across the distributed systems it has developed for its own telecommunications operations. Furthermore, features have been built into UNIX^{TM} to allow UNIX-based Systems to communicate readily with Systems running on IBM-type systems or even personal computers.

Furthermore, digital switching systems are now commonly using standard protocols (e.g., X-2J) for input and output. This allows exogenous Systems to transfer data to and from the computer processor of these switching systems.

However, the common thread among many different integrated Systems is the data that the applications share. As a part of the Operations Planning exercise, it is essential that common data elements be defined and a common data dictionary be used. With this data in place, the application may be implemented separately and brought on-line as they are required.

A highly schematic example of a distributed systems architecture is shown in Figure 1.

Figure 1 - Hypothetical Example of Distributed Systems Architecture



SCS: Switching Control System
SOP: Service Order Processor
T: Terminals
OSP: Outside Plant
DBMS: Database Management System
DK: Data Communications Network
DBD: Database Dictionary

The larger circles represent self-contained distributed applications that are integrated with a star-type network.

5. INTEGRATION OF SYSTEMS INTO OPERATIONS

To be beneficial, Systems must be used. Hence, Systems should be designed to be user-friendly and to assist workers and managers (the users) in carrying out their jobs.

5.1 SYSTEM SIMULATION

AT&T has widely used the techniques of system simulation and prototype system design to ensure that Systems are designed to meet user needs. After Operations Planning has determined the functions to be computerized, Human Factors Engineers (typically psychologists) work with groups of users to create the screens that will serve as the human interface to the System. The System is then built backward from these screens in a way that is consistent with the longer term view of the Operations Plan and the Operations Function. At various stages of the System implementation, the System functions are simulated to ensure that the design will not require significant modification once development has begun.

5.2 TRAINING

The simulated system is also used to train users. We have found tremendous benefits in training the users before live cutover of Systems. The "fear factor" involved in the introduction of a System will often lead to rejection by workers. A rigorous training program before introduction can promote wide user acceptance.

Training should continue during and after System cutover.

5.3 DOCUMENTATION

Documentation for System's users should be completed and up-to-date. AT&T has found that on-line documentation that is current with System generic is a strong benefit.

Often System generics are released every few months and System documentation follows by an equivalent time interval. Hence, all System manuals are always out-of-date. On-line documentation delivered with the new generic is the solution to this dilemma.

6. CONCLUSION

Operations Planning provides a framework to plan for the computerization of telecommunication operations. Without this framework, many of the benefits of a Digital World cannot be recognized. For example, modern digital switching systems can be remotely administered, surveilled, and controlled. Without a good plan and appropriate computerization, these benefits may become detriments.

As computer technology evolves toward vertically integrated, distributed systems, the initial cost of implementing Operations Systems is falling rapidly. The introduction of UNIX™ and related computer operating systems that are able to run on small-sized, relatively inexpensive minicomputers has shortened the development intervals for Systems.

Operations Planning can be the vehicle for telecommunications managers to operate their networks in the Digital World.

SATELLITES VERSUS FIBER OPTIC CABLES

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ABSTRACT

This paper compares the capacity and cost of the new fiber optic submarine cables and the state-of-the-art INTELSAT VI satellites. The results indicate that contrary to generally accepted beliefs, satellites are cheaper than fiber optic cables on a per circuit point-to-point basis. Moreover, overall connectivity capability, in addition to simple point-to-point capacity, is expected to be very important in the choice of future facilities on a cost effective basis. Advances in technology have virtually overcome the problems associated with propagation delay inherent in satellite transmissions. Finally, satellites and cable systems should be considered complementary means of transmission, with the choice in any given situation based upon the overall relative strengths of each, including cost effectiveness, in relation to the need.

1. INTRODUCTION

There has been a lot of recent publicity concerning the revolution in cable technology for telecommunications . It has been stated that the new digital fiber optic technology for submarine cables would permit very large capacity facilities with a significantly lower per circuit cost than for satellites. Prior to this revolution in cable technology, the use of satellites for international communications was favored in most cases purely on economic grounds, although satellites and cables were complementary from a media diversity point of view. However, the general view now being publicized is that the fiber optic cable is significantly cheaper than satellite alternatives, with the implication that on economic grounds a significant amount of traffic must shift from satellites to cables over the next decade. Moreover, it has been stated that propagation delay in the satellite has strengthened the case further in favor of fiber optic submarine cables.

The purpose of this paper is to examine these claims and separate myth from reality by comparing satellites and fiber optic cables on an appropriate basis. Section 2 contains a cost and capacity comparison of satellites and cables. Section 3 addresses the issue of connectivity. Section 4 discusses propagation delay. Finally, Section 5 contains the conclusions of the analysis.

2. COST AND CAPACITY COMPARISON

In order to examine the validity of the claim that fiber optic cables are cheaper than satellites, an accurate and appropriate comparison must be made. The difficulty is that satellites and cables operate differently and there are many complex factors that affect the comparison. Most of the results being publicized show fiber optic cables less expensive than satellites by comparing the cost per circuit of a single completely full fiber optic cable facility with the tariff rate for an INTELSAT voice circuit. This means that the capital and operating costs of a single, advanced technology, 100% full, fiber optic cable facility is being compared with a tariff rate that embodies a mix of satellite facilities ranging from a relatively low capacity INTELSAT IV to plant under construction for the state-of-the-art INTELSAT VI spacecraft. This tariff rate also represents less than full utilization of the satellites in operation. This type of comparison is misleading in evaluating the relative economies and efficiencies of the latest cable and satellite technologies.

A more appropriate method of assessing the relative cost efficiencies of the two technologies is to examine the cost per circuit for a fully loaded fiber optic cable facility, such as the TAT-8 cable due to be placed in service across the Atlantic in 1988, with the cost per circuit for a comparably equipped fully loaded INTELSAT VI satellite. Details of this comparison are contained in Attachment No. 1. Two different configurations of the INTELSAT VI spacecraft are used in the comparison. One is an operational configuration designed to operate in a multiple access mode capable of interconnecting hundreds of different geographical locations. The other configuration is a maximum capacity utilization mode of operation utilizing a single carrier for each transponder and designed to interconnect relatively few locations -- similar to a typical cable system configuration. Circuit capacity is estimated for both satellite configurations and the TAT-8 cable. These range from an estimate of basic bearer circuits to a maximum capacity measured in derived circuits based upon low rate encoding and circuit multiplication techniques.

Both satellite configurations assume access via three large Standard A earth stations located at each of the three TAT-8 landing points (U.S., U.K., and France). This ensures a fair comparison by providing a similar communication capability. That is, the satellite is configured to operate like a cable in the sky connecting the three cable landing points. Each of the three satellite earth stations is assumed to contain R.F., I.F. and modem equipment designed to operate only with large carriers, since the cost of the TAT-8 cable includes only 140 Mbps. digital interface terminal equipment.

The capital costs for both facilities (i.e. the INTELSAT VI satellite and TAT-8 cable system) are assumed to be incurred in 1987 and are represented as a lump sum, present value, capital cost in Table 1 of Attachment No. 1. An annualized capital cost estimate is obtained from this figure based upon a 25 year life for the cable and a 10 year life for the satellite using a 14% discount rate. This annualized cost is a constant dollar stream of payments over the life of the facility whose present value (using a discount rate of 14%) equals the lump sum capital cost of the facility(1). The capital costs of the three Standard A earth stations are treated in the same manner assuming a 15 year life for each facility. Overhead and operations and maintenance expenses for the cable are assumed to be 13.75% of the annualized capital cost incurred each year. Overhead and operations and maintenance expenses for the INTELSAT VI spacecraft are assumed to be 25% of the annualized capital cost incurred on an annual basis, and 15% of the annualized capital cost for the earth stations.

The comparative analysis, shown in detail in Table 1 and Figure 1 of Attachment No. 1, yields the following results:

i) the capacity of the INTELSAT VI is 1.6 (operational configuration) to 3.6 (Maximum capacity configuration) times greater than TAT-8;

ii) the annualized cost of the INTELSAT VI (including earth stations) is 12% higher than the TAT-8 cable system;

iii) therefore, assuming 100% fill of both facilities, the annual costs per circuit are:(2)

INTELSAT VI		TAT-8
Operational Configuration	Maximum Capacity	
$1133/Cir.	$504/Cir.	$1596/Cir.

These results indicate clearly that when satellites are compared with the fiber optic cable on an appropriate basis, satellites have lower unit costs. This result is contrary to generally accepted beliefs.

The TAT-8 cable facility is approximately 6500 kilometers in length. It is estimated that the capital cost of the facility increases by approximately $36,000.00 for each additional kilometer of length. Therefore, the cost per circuit for a Trans-Pacific cable from the U.S. to Japan would be approximately $2,237 per circuit per year. Since this cost is 40% higher than for TAT-8, the INTELSAT VI has an even bigger cost advantage over fiber optic cables on the longer Trans-Pacific routes.

Capacity of the fiber optic cable can be increased by including additional fiber pairs in the cable. It is estimated that each additional fiber pair increases the overall capital cost of the cable by approximately 10%. However, even though capacity can be added to a basic fiber optic system at a relatively low incremental cost, projected circuit demand levels in the late 80's and 90's suggest that additional capacity beyond the basic 2 fiber pair system would be far greater than the amount needed to meet demand to most locations.

3. CONNECTIVITY

A fiber optic cable is essentially a direct point-to-point facility. The technology has developed to permit limited branching from offshore points. The costs of a separate branch are very high, however, and branching is only cost effective in connecting very large traffic streams to the main cable system. Moreover, the trend in the development of fiber optic technology is toward greater increases in maximum capacity for a single facility. This suggests that the technology is far ahead of the needed demand for circuit capacity between terminal points. Therefore, in order to utilize fiber optic submarine cable facilities efficiently, either extensive terrestrial or satellite networks are needed in conjunction with the cables to carry traffic beyond the terminal points of the cable. A distinct advantage of satellite technology is the extensive connectivity available through a single facility. One satellite is capable of

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serving directly an extremely large number of points located within the beam coverage of the satellite. For example, INTELSAT's Atlantic Ocean Region satellite currently accommodates 448 independent traffic paths covering North America, South America, Europe, Africa, and the Middle East. New paths are created simply by adding additional earth stations to access the satellite. Furthermore, satellite technology is such that the cost of providing service is essentially distance insensitive within the beam coverage of the satellite. This means that it costs no more to deliver the signal directly to the user than it does to downlink through a coastal earth station, which then requires the use of additional terrestrial facilities to deliver the signal ultimately to the user. A key point to stress is that state-of-the-art satellites and cables both have capacities far in excess of projected point-to-point requirements to most locations; therefore, the cost effective use of transmission facilities will depend critically on connectivity capability. This suggests that "economies of scope" as well as "economies of scale" should be considered in evaluating satellites and cables.

4. PROPAGATION DELAY

Recurring claims have been made that satellite transmission facilities are inferior to cable systems because of the propagation delay inherent in transmitting 22,500 miles up and back to the earth's surface. Developments in echo suppression technology have virtually eliminated propagation delay problems associated with voice transmissions carried on satellites; it is now extremely difficult to tell when a phone conversation is being transmitted via cable or satellite. Also, delay compensation units have been developed for data transmissions via satellite. This has resulted in extremely satisfactory satellite data services.

5. CONCLUSIONS

The analysis has demonstrated that when satellites and fiber optic cables are evaluated on a comparable basis, satellites are less expensive than cables. Moreover, connectivity capability, not point-to-point pipeline capacity, is the key to cost effective use of communications transmission facilities in the 1980's and 1990's, since the overall capacity available in both satellites and cables exceeds the foreseeable demand. Satellites have a significant advantage over cables in providing connectivity due to distance insensitive costs, broad geographical coverage, and extensive multiple access capability. Furthermore, great strides have been made in overcoming the inherent propagation delay in satellite transmissions.

Finally, satellites and fiber optic cable systems should be considered as complementary, since both are needed to efficiently meet communications needs in the 1980's and 1990's. Therefore, the focus of attention should be upon the evaluation of which type of facility is best in a given situation, based upon the overall relative strengths of each, including cost effectiveness, in relation to the need.

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(1) This annualized cost is equivalent, in present value terms, to a stream consisting of straight-line depreciation payments and a return on net book value of 14%. Also, the annualized cost adjusts for the different estimated lives of the two facilities, since it is equivalent to continuous replacement of each facility at end-of-life, assuming a constant replacement cost. A sensitivity analysis was conducted using a higher discount rate of 17%. This shifted the results even more favorably toward the satellite.

(2) The relative difference in cost per circuit between satellite and cable will not change if less than 100% fill is assumed, as long as the percentage utilization is the same for both facilities. For example, if 25% fill is assumed, the per circuit costs are \$4,534 and \$2,016 for the two satellite configurations and \$6,384 for TAT-8.

ATTACHMENT NO. 1

TABLE NO. 1

CAPACITY AND COST COMPARISON

	INTELSAT VI		TAT-8
CAPACITY IN CIRCUITS	OPERATIONAL	FULL CAPACITY	
BASIC BEARER	22500	26902	7560
FM+TDMA/DSI--->	35000		
DSI(90% VOICE;10% DATA)---->		63220	17766
LRE,FM,CFM,TDMA/DSI MIX----->	55000		
LRE(32KBPS,90% VOICE,10% DATA)->		123750	34776
COST ESTIMATES			
CAPITAL COST(1987)	$232,000,000	$232,000,000	$335,400,000
EXPECTED LIFE IN YEARS	10	10	25
ANNUAL CAPITAL COSTS(14%)	$44,477,541	$44,477,541	$48,800,166
EARTH STATION CAPITAL COSTS (3)	$36,000,000	$36,000,000	
EXPECTED LIFE IN YEARS	15	15	
ANNUAL CAPITAL COSTS([illegible]%)	$5,861,123	$5,861,123	
TOTAL ANNUALIZED CAPITAL COSTS	$50,338,664	$50,338,664	$48,800,166
OVERHEAD AND O&M EXPENSES			
YEARLY CABLE (13.75% OF YEARLY CAPITAL)			$6,708,000
INTELSAT VI 25% OF YEARLY CAPITAL	$11,119,385	$11,119,385	
E/S 15% OF YEARLY CAPITAL COSTS	$879,168	$879,168	
TOTAL ANNUALIZED OVERHEAD AND O&M	$11,998,554	$11,998,554	$6,708,000
TOTAL ANNUALIZED COSTS	$62,337,218	$62,337,218	$55,508,166
YEARLY COSTS PER CIRCUIT			
CAPITAL	$915	$407	$1,403
OVERHEAD AND O&M	$218	$97	$193
TOTAL COSTS------->	$1,133	$504	$1,596
RATIO IS-VI/TAT-8	71.01%	31.56%	
	INTELSAT VI		TAT-8

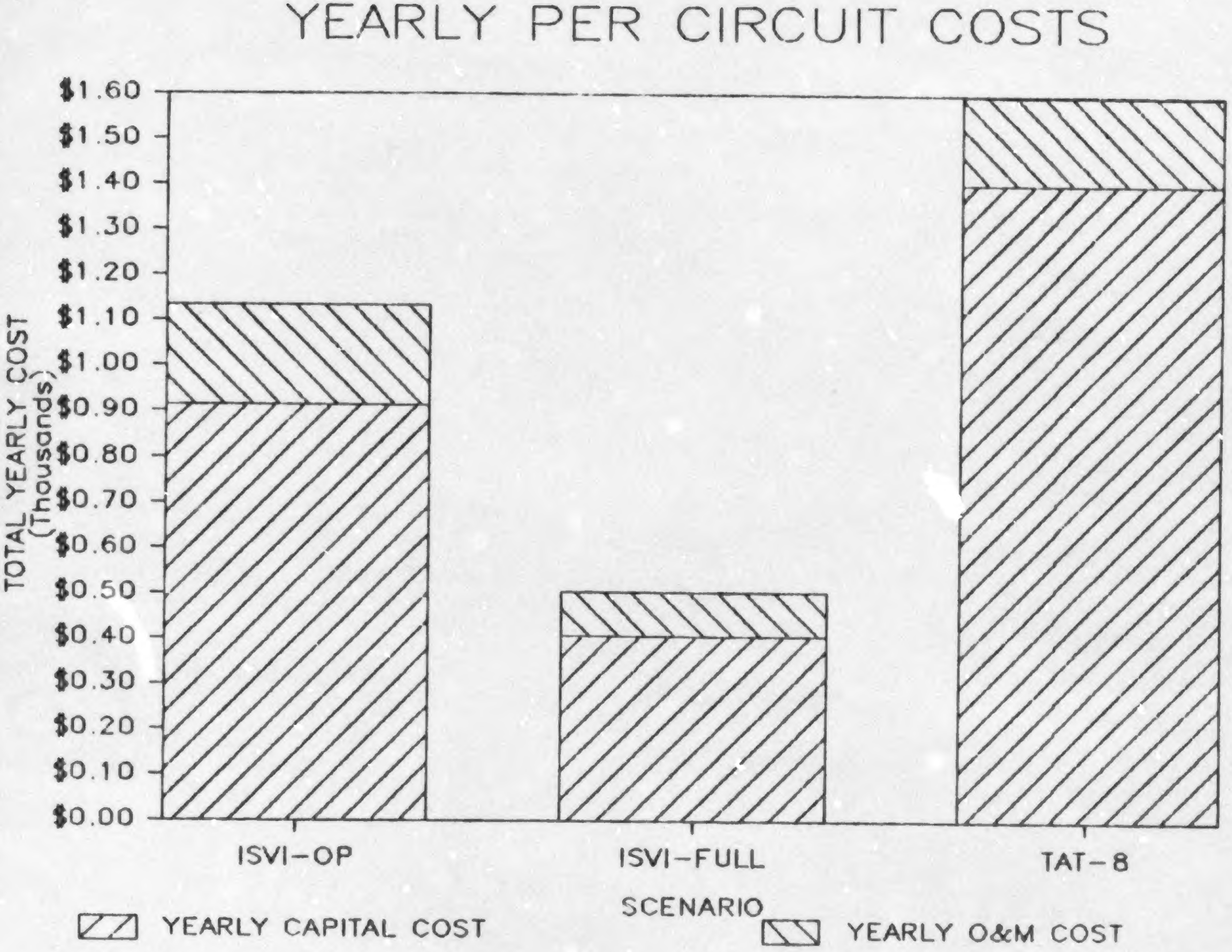

FIGURE NO. 1

ATTACHMENT NO. 1
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